OPERATING AND MAINTENANCE INSTRUCTION MANUAL

MODEL 706

FM / FMX™ STEREO GENERATOR

INOVONICS
INCORPORATED

- USER'S RECORD -

Model 706 - Serial No. ________

Date Purchased ______________

Warranty Card Mailed __________

OPERATING AND MAINTENANCE INSTRUCTION MANUAL

MODEL 706

FM / FMX™ STEREO GENERATOR

May, 1991

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TABLE OF CONTENTS

Section I - INTRODUCTION

Model 706 Product Description 3
General - Additional Features

Audio Pre-Processing Requirements 3
Preemphasized Transmission - Split-Spectrum Peak Control - Internal Overmod Protection

The FMX^{tm} "Coverage Extension" Transmission System. 4
Product Background - General - Companded Quadrature Modulation - The FMX^{tm} Stereo Receiver

Model 706 Specifications 6
Specifications - Block Diagram - Patent Notices

Section II - INSTALLATION

Unpacking and Inspection 9

Mounting 9
Rack Requirement - Heat Dissipation

AC (Mains) Power 9
As-Delivered - Voltage Selector - Power Cord

Radio Frequency Interference (RFI) 10
Location - Ground Loops

Line Input and Input Range Selection 10
"Main" Inputs - Termination - Level Range Selection - Auxiliary Input

Preemphasis Selection 11

Subcarrier Inputs 12

Remote Control Selection 12
Remote MONO / STEREO - Remote FMX^{tm} ON / OFF

Composite Outputs 12

19kHz Output. 13

Installation of the FMX^{tm} System Option 13
"Dummy Plug" - Mounting - R84 Removal

Section III - SETUP AND OPERATION

Panel Controls and Indicators 14
(All Controls and Indicators Defined According to Function)

Bargraph Metering 16

Initial Setup Procedure 16

FMX^{tm} System Setup and Operation 18

Composite Equalization and Phase Adjustment 19

FMX^{tm} System Performance Considerations 21

Source Components - Relay Components - Transmission Components - Recommended Reading

Implications of "Composite Processing" 21

Pilot Modulation - Out-of-Band Components

Section IV - CALIBRATION

Internal Calibration 24

Equipment Required - Preset and Power-Up - Input Circuit Level Check and Set - Low-Pass Filter Adjustment - Filter Overshoot Compensation Adjustments - Output Level Set - Pilot Distortion Null - SCA/RDS Level Verification - FMX^{tm} Plug-In Option Calibration

Section V - CIRCUIT DESCRIPTIONS

Parts Location Note 30

Circuit Descriptions 30

Input Circuitry - Filter Overshoot Compensator - Low-Pass Filter - Subcarrier and Pilot Generation - Combining and Output Filter Circuitry - Metering Rectification/Rectification - Bargraph Display Circuitry - Remote Function Control - Power Supply - FMX^{tm} System Option

Section VI - APPENDIX

Parts Lists - Schematics - Warranty 39

Section I

INTRODUCTION

MODEL 706 PRODUCT DESCRIPTION

General

Inovonics' 706 is the firm's second-generation FM Stereo Generator ("Stereo Coder" in Europe) which includes the FMX^{tm} "Coverage Extension" Transmission System as an easily-installed plug-in option. The FMX^{tm} System is discused in more detail at the end of this Section.

The 706 Generator incorporates the necessary preemphasis and low-pass filtering functions required in customary broadcasting practice, and features patented compensation circuitry to avoid modulation sacrifices due to overshoots in the primary low-pass filter. FM subcarrier(s) and Pilot are digitally synthesized for optimum and adjustment-free operation.

Additional Features

Several other features have been designed into the 706 to increase its versatility and to aid in its setup and operation; these set it apart from Inovonics' more basic Stereo Generator, the Model 705. New features include:

- Remote control over STEREO/MONO switchover and FMX^{tm} ON/OFF.
- Front-panel metering of important internal signal levels to facilitate setup and verify operation.
- Internal combining for up to three SCA or RDS subcarrier channels.
- Separate 19kHz TTL-level output to phase-sync RDS encoder equipment.
- A built-in Composite Processor which may be adjusted for clipping between 0dB and 3dB.
- Comprehensive variable equalization over both amplitude and phase response of the composite signal to compensate for deficiencies in other parts of the transmission system.
- Fully compatible with all Inovonics and most other audio processing systems. A separate set of program inputs interfaces directly with popular processor/generator combination units.

AUDIO PRE-PROCESSING REQUIREMENTS

Though two forms of overmodulation protection circuitry are included in the 706, it is anticipated that the Generator will be preceded by some form of "audio processing" system which places a ceiling on program peaks with specific allowances for "protection" of the preemphasis characteristic. It is essential that this need for *split spectrum* audio processing be understood and met.

Preemphasized Transmission

In FM broadcasting a high frequency *preemphasis* (high-end boost) characteristic is imparted to the input program signal prior to transmission. At the receiver a complementary *deemphasis* (high-end rolloff) network restores overall flat frequency response. The purpose of this exercise is to reduce the high frequency noise which is inevitably added in transmission. This noise is generally worse for listeners who are farther from the broadcasting station.

If a low frequency tone (300Hz) is applied to the transmitter at a level which yields 100% carrier modulation, a high frequency tone (10kHz) applied at the *same* level would overmodulate the carrier (400% or more) because of the transmission preemphasis curve. Fortunately, normal voice and music program signals have comparative low energy at the higher frequencies, and actual statistics of program spectral composition were taken into account when the preemphasis characteristic was established years ago. Nevertheless, occasional high energy, high frequency peaks (sibilants, cymbals, etc.) can still cause carrier overmodulation, even when program peaks are broadband-limited to 100%-modulation values. This is especially true when modern-day recordings of contemporary music are the program source.

Split-Spectrum Peak Control

A preemphasis network *ahead* of a broadband limiter, and a deemphasis circuit *following* it, will deal with this situation, though the overall level will "duck" whenever a high-end peak occurs. This imparts a "choppy" sound to the program and reduces both intelligibility and perceived loudness. What is instead required is a program limiter operating as a dual-band device with a *broadband* section to cope with normal program peaks, and an *independent* high frequency limiter section (with proportionally faster time constants) to deal with those program components subject to accentuation by the transmission preemphasis characteristic. A limiter of this type, now common in both FM and AM broadcasting systems, has negligible audible effect on most program material while providing absolute protection from carrier overmodulation.

Internal Overmod Protection

Overmod protection circuitry internal to the 706 starts with a complex, active peak *clipper* integral with the low-pass filter overshoot compensator. Because of its unique mode of operation, a good deal more peak clipping may be tolerated than with more simple signal clipping circuits. The 706 may, in fact, even be used "barefoot" or with minimal audio pre-processing, yet still yield quite acceptable and "competitive" performance. The 706 also features a built-in Composite Processor which can be adjusted to clip as much as 3dB into the composite signal *prior to 19kHz Pilot insertion.* While this technique can be used to increase relative loudness, it is at the expense of introducing spurious harmonic products above the 54kHz upper band-edge of the stereo composite signal.

THE FMX^{tm} "COVERAGE-EXTENSION" TRANSMISSION SYSTEM

Product Background

Development of Inovonics' Model 705 Stereo Generator in 1987 was actually inspired by Torick and Keller's 1983 invention of the FMX^{tm} System (U.S. Pat. 4,485,483), and the improvements it implied for the entire FM broadcasting industry. Both the 705 and 706 Generators were designed from the beginning to accept and support an optional plug-in circuit card for the FMX^{tm} System, leaving the "whether" and "when" at the discretion of the individual broadcaster.

General

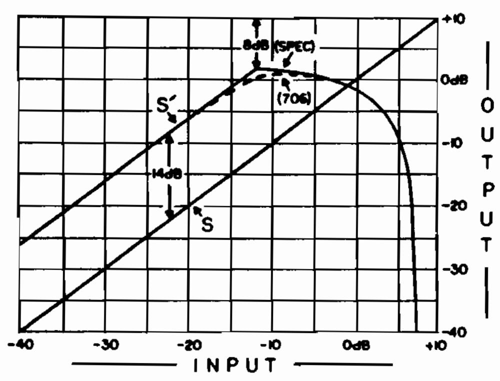
"*FMX*" is the registered tradename for a patented, improved system of FM stereo broadcasting which is fully compatible with the customary standards and practices used throughout the world. This means that not only can FMX^{tm} Stereo transmissions be received by existing mono and stereo receivers with no performance compromises, but a new generation of FMX^{tm} Stereo receivers can provide the broadcaster with a substantial increase in stereocasting coverage (up to 400% is claimed by the inventors), nearly equalling the noise-free coverage of mono reception.

The plug-in-option circuit assembly for the FMX^{tm} System currently available from Inovonics contains all updates provided by the System Licensor, Broadcast Technology Partners, as of the date of manufacture. Furthermore, since FMX^{tm} circuitry may be user-installed in a matter of minutes, any future updates are very easily implemented.

Companded Quadrature Modulation

The FMX^{tm} System employs a second, *quadrature* subcarrier at the same 38kHz as the normal L-R signal, but with a 90-degree phase offset. This additional subcarrier is modulated by *compressed* L-R program information which is *expanded* in the FMX^{tm} Stereo receiver for a much-improved signal-to-noise figure.

The compression transfer function (input vs. output) of the quadrature subcarrier, *S'*, has a *reentrant* or dynamic inversion characteristic; that is, the level of *S'* reaches a maximum value, then begins to drop - even as the input continues to increase - until it "shuts off" completely. *S'* shutoff coincides with the maximum, 100%-modulation level of the normal stereo subcarrier, *S*. Thus total modulation, including the L+R "main channel" component, *M*, $(M + S + S')$ never exceeds the usual 100% value of the "interleaved" stereo program signal. The FMX^{tm} System compression function is graphed in Figure 1.



This graph shows both the transfer function (input vs. output) of the Model 706 FMX^{tm} System Compressor, and the relationship of S' to the normal subcarrier, S. +10dB is an internal signal level corresponding to 100% modulation of the L-R subcarrier. With a nominal 10% Stereo Pilot insertion, this +10dB level would then represent 90% modulation of the total "composite" stereo signal.

Figure 1 - FMX^{tm} System Compression Characteristic

The FMX^{tm} Stereo Receiver

The FMX^{tm} Stereo receiver has a dual demodulator which independently recovers program information from both the *S* and *S'* subcarriers. Because both signals are always available, "servo" techniques may be used in the complementary expansion process. This obviates the perfect tracking of levels and time constants demanded by most traditional compander schemes. Dematrixed and recovered Left and Right program channels are thus optimized for best S/N at low levels.

MODEL 706 SPECIFICATIONS

Frequency Response (preemphasis defeated):
±0.25dB, 25Hz - 16kHz; -25dB or better at 10Hz, -60dB or better at 19kHz.

Stereo Separation (L/R or R/L):
>70dB, 25Hz - 10kHz; >60dB, 10kHz - 16kHz.

Crosstalk:
Main-to-Sub, -70dB or better; Sub-to-Main, -65dB or better.

Distortion:
<0.05% THD in demodulated audio 1dB or more below 100% modulation; Mono or Stereo mode, 25Hz - 16kHz.

Noise:
Better than 85dB below 100% modulation in demodulated audio, Mono or Stereo; "spectral" noise components in Composite Output better than 75dB below 100% modulation, 25Hz - 1MHz.

Preemphasis:
50μs or 75μs, user-selectable; ±0.5dB over curve.

Stereo Pilot:
19kHz, ±1Hz; injection level adjustable between 6% and 12%, relative to 100% modulation. Pilot distortion <0.5% THD.

Program Inputs:
"Main" Left and Right program inputs are active-balanced, bridging; accept line input levels between -15 and +15dBu. (0dBu = 0.775V r.m.s.) Alternate, single-ended inputs bypass preemphasis and input conditioning circuitry; optimized for input level of +12dBu (9V p-p), ±3dB.

Input Filtering:
7-pole, phase-corrected, active-elliptic "FDNR" low-pass; fifth-order Chebyshev high-pass.

Overmodulation Protection:

PRIMARY - Integral part of input filter overshoot circuit; defeatable with same.

SECONDARY - "Composite Processor" permits between 0dB and 3dB clipping of the composite stereo signal prior to 19kHz Pilot insertion.

SCA / RDS Inputs:
Single-ended; accept input levels between -5 and +10dBu for 10% modulation.

Composite Outputs:
Two independent single-ended "zero impedance" outputs; adjustable between -5 and +12dBu (0.5 to 3V r.m.s. or 1.2 to 8V p-p).

Pilot Output:
TTL-level symmetrical squarewave in-phase with 19kHz Stereo Pilot in composite output signal.

Remote Control:
Requires momentary contact closures to ground to switch FMX^{tm} System ON and OFF, or to switch to MONO operation from Left or Right or L+R, or to return to STEREO mode. Generator defaults or "wakes up" in STEREO mode with FMX^{tm} System ON.

Digital Synthesis Sampling Rate:
608kHz (16X subcarrier oversampling).

Power Requirement:
105 - 130VAC or 210 - 255VAC, 50/60Hz; 8 watts.

Size and Shipping Weight:
3½"H X 19"W X 10"D (2U); 10 lbs.

BLOCK DIAGRAM

A simplified Block Diagram of the 706 Stereo Generator *signal path* is shown on Page 8. Power supply, local and remote function switching, and display sections are *not* included in this diagram. Generator circuitry is explained in detail under Circuit Descriptions, Section V, which references the complete set of schematic diagrams contained in the Appendix, Section VI.

PATENT NOTICES

Low-pass filter overshoot compensation circuitry employed in the Model 706 Stereo Generator is covered under U.S. Patent No. 4,737,725.

The FMX^{tm} Transmission System is protected by U.S. Patents Nos. 4,485,483; 4,602,380; 4,602,381 and others pending. The plug-in-option circuit assembly for the Model 706 Stereo Generator is manufactured by Inovonics under license from Broadcast Technology Partners (BTP) of Bloomfield Hills, Michigan.

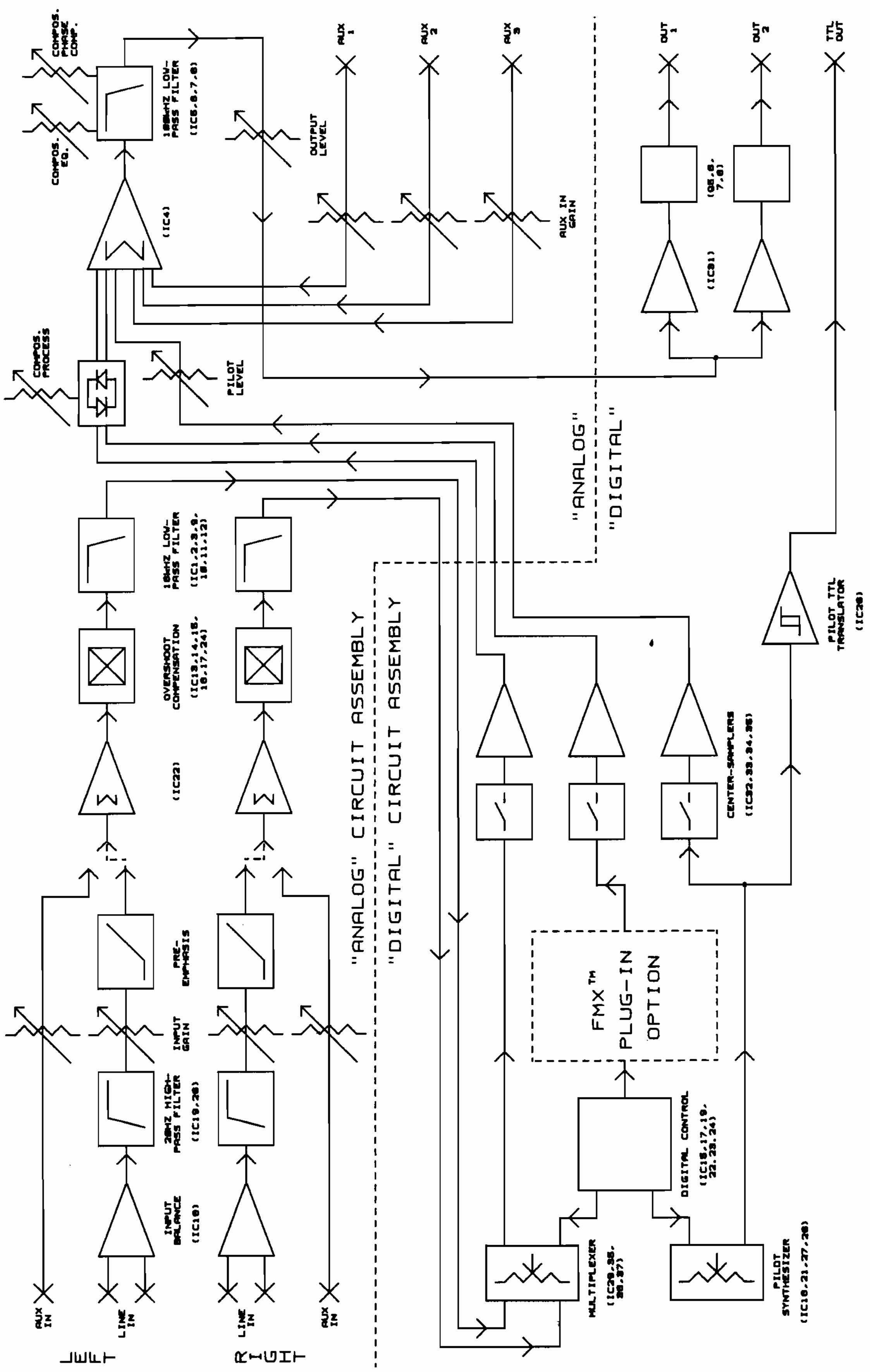


Figure 2 - Block Diagram, Model 706 Stereo Generator

Section II

INSTALLATION

UNPACKING AND INSPECTION

Immediately upon receipt of the equipment, inspect carefully for shipping damage. If any damage is observed, notify the carrier at once; if not, proceed as outlined below. It is recommended that the original shipping carton and packing materials be saved should future reshipment become necessary. In the event of return for Warrant repair, shipping damage sustained as a result of improper packing for return may *invalidate the Warranty!*

IT IS VERY IMPORTANT that the Warranty Registration Card found at the front of this manual be completed and returned. Not only does this assure coverage of the equipment under terms of the Warranty, and provide some means of trace in the case of lost or stolen gear, but the user will automatically receive specific SERVICE OR MODIFICATION INSTRUCTIONS should they be issued by the factory.

MOUNTING

Rack Requirement

The Inovonics 706 is packaged to mount in a standard 19-inch equipment rack and requires only 3½ inches (2U) of vertical rack space. Because the Generator does not have appreciable weight, only two mounting holes are provided. These holes are positioned in accordance with "preferred" current EIA Specifications, but may not align with tapped holes in the mounting rails of some equipment racks manufactured before 1958. *The use of plastic "finishing" washers is recommended to protect the painted finish around the mounting holes.*

Heat Dissipation

The left-hand side of the aluminum chassis is used as a heatsink for power supply voltage regulators. In normal operation this side of the enclosure becomes quite warm to the touch.

The 706 should be located such that air is free to circulate around the chassis. It should not be mounted adjacent to equipment which generates appreciable heat, except in cabinets which provide forced-air ventilation. The *ambient* operating temperature of the 706 should not exceed 50°C.

AC (MAINS) POWER

As-Delivered

Unless specifically ordered for export shipment, the 706 is delivered from the factory for operation from 125V, 50/60Hz AC mains. The back-panel designation next to the fuseholder will confirm both the mains voltage selected and the value of the fuse to be used.

Voltage Selector

There is a mains voltage selector switch beneath the top cover of the Generator, at the rear of the main circuit board adjacent to the fuseholder. *With mains power removed,* slide the red switch actuator with a small screwdriver so that the proper nominal mains voltage (115 or 230) shows. An appropriate fuse must always be installed, and the back-panel voltage/fuse designation marked. It is factory practice to cross out the *inappropriate* markings with black felt marking pen. This strikethrough can be removed with solvent if the markings need to be changed.

BE SURE that the mains voltage selector setting and primary fuse value are appropriate for the mains supply before plugging the 706 Generator into the wall socket.

Power Cord

The detachable power cord supplied with the 706 Generator is fitted with a North-American-standard male connector. The individual cord conductors are *supposedly* color-coded in accordance with CEE standards:

BROWN = AC "HOT," BLUE = AC NEUTRAL, GRN/YEL = GROUND.

If this turns out *not* to be the case, we offer our apologies (cord vendors vary) and advise that U.S. color coding applies:

BLACK = AC "HOT," WHITE = AC NEUTRAL, GREEN = GROUND.

RADIO FREQUENCY INTERFERENCE (R F I)

Location

Though the 706 has been designed to operate in close proximity to broadcast transmitters, care should be exercised in locating the unit away from *abnormally* high RF fields.

Ground Loops

In some installation situations an RF ground loop may be formed between the input or output cable shield grounds and the AC power cord ground. Use of a "ground-lifting" AC adapter should remedy the problem, though the chassis must ultimately be returned to earth ground for safety.

LINE INPUT AND INPUT RANGE SELECTION

"Main" Inputs

The Model 706 has electronically-balanced (transformerless), bridging (10K-ohms or greater) Left and Right primary Line Inputs. These are brought out to the "upper" rear-panel barrier strip and include chassis ground connections for cable shields.

Termination

Should the equipment which *feeds* the Generator require output loading, 600-ohm terminating resistors may be placed across the 706 input terminals.

Level Range Selection

The 706 accepts "zero-reference" program input levels between -15 and +15dBu (0dBu = 0.775V r.m.s.) This 30dB input level range is divided into two, more manageable 15dB segments which correspond to the range of the "L" and "R" LINE IN, INPUT GAIN controls.

There are two sets of dual jumper strips under the top cover, just behind the LINE IN barrier strip on the upper (Analog) circuit board. These strips are labeled

J9, J10, J11 and J12. The two positions for range selection jumper "shunts" are marked in the board legend: "H" for HIGH level, 0 to +15dBu; "L" for LOW level, -15 to 0dBu. Figure 3 shows the jumpering options. As shipped, the 706 is jumpered for HIGH level inputs.

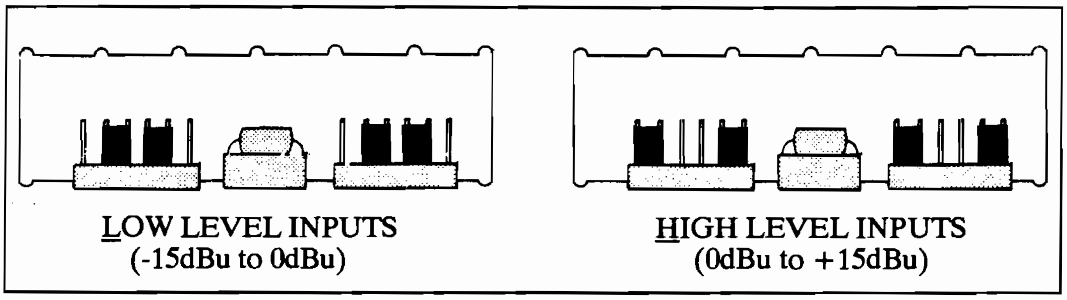


Figure 3 - "Main" Line Input Range Selection

Auxiliary Input

A separate "auxiliary" program input is provided on the rear panel of the 706 Generator. This is a pair of single-ended, unbalanced line inputs specifically level-matched to accept the processed, preemphasized "test jack" audio output from a popular Processor/Generator combination product in widespread use.

The rear-panel AUX IN input is selected by removing the top cover and changing a pair of jumper "shunts" on the upper (Analog) circuit board. Two jumper strips, labeled J15 and J16, are located about midway between the LINE IN barrier strip and the front sub-panel INPUT GAIN controls. The positions for normal line-level inputs (NORM) and auxiliary inputs (AUX) are marked in the board legend. Figure 4 shows the two jumpering options. As shipped, the 706 is jumpered to accept the normal (NORM) LINE IN.

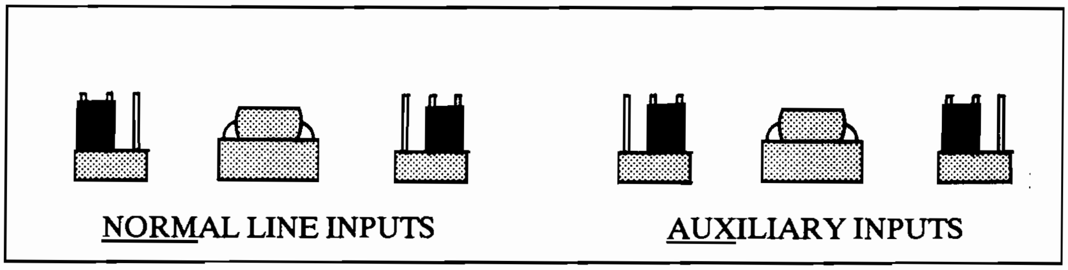


Figure 4 - Line Input Selection

PREEMPHASIS SELECTION

Both 75-microsecond (U.S.) and 50-microsecond (European) FM broadcasting preemphasis standards are readily accommodated. Two jumper strips, labeled J13 and J14, each with a jumper "shunt," are located beneath the top cover on the upper (Analog) circuit board, behind the LINE IN barrier strip and about one-third the distance to the front sub-panel INPUT GAIN controls. The 75μs and 50μs positions are clearly marked in the circuit board legend, and Figure 5 shows the jumpering options. When shipped, the 706 is jumpered for the intended destination.

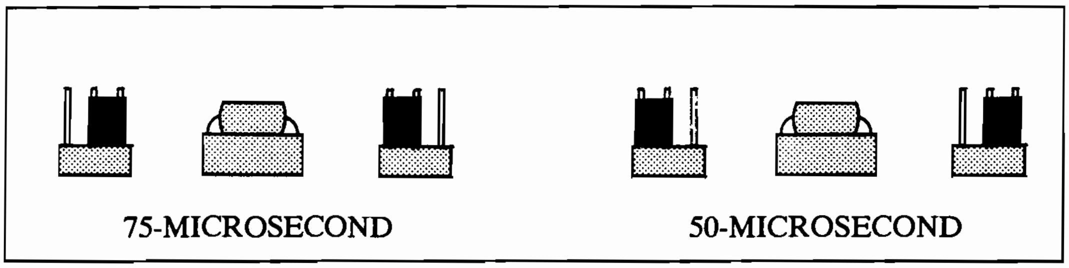


Figure 5 - Preemphasis Selection

SUBCARRIER INPUTS

The 706 features three independent inputs for SCA or RDS subcarriers in the 56 - 100kHz range. These inputs are single-ended with a resistive input impedance of 1k-ohms. The input level range is between -5 and +10dBu (0dBu = 0.775V r.m.s.) for *10% modulation* of the composite output signal. The injection level is set with the SUBCARRIERS 1, 2 and 3, INPUT GAIN controls on the front sub-panel.

REMOTE MODE SELECTION

Provision is included in the Model 706 for remote selection of MONO / STEREO and FMX^{tm} System ON / OFF. A *momentary* contact closure (or NPN transistor saturation) to ground initiates each command. Remote Control inputs appear on the lower, rear-panel barrier strip, and are "debounced" within the 706. Typical transmitter Remote Control "UP/DOWN" logic can provide convenient control of these functions.

Remote MONO / STEREO

The Generator may be placed in monaural operation with the input derived either from the Left channel source (MONO L), the Right channel source (MONO R), or from Left-plus-Right (MONO SUM). Applying ground to the ST terminal returns the unit to the normal, Stereo mode. (Stereo operation is the normal "wake-up" state.)

Remote FMX^{tm} ON / OFF

When the FMX^{tm} System plug-in option is installed in the 706, it may be remotely turned ON and OFF with momentary ground applications. (The normal "wake-up" state is with FMX^{tm} ON, when the option is provided.)

COMPOSITE OUTPUTS

Two, separately-buffered Composite Outputs are provided. These single-ended outputs have a "zero impedance" voltage-source characteristic and are able to drive long cables or other complex loads without exhibiting instability. Though the two outputs are otherwise independent, they are simultaneously adjusted by the single COMPOSITE LEVEL control on the front sub-panel.

19kHz OUTPUT

A rear-panel BNC connector delivers a TTL-level 19kHz symmetrical squarewave, in-phase with the 19kHz Stereo Pilot component in the Composite Output. This logic-level signal may be used to phase-lock RDS or other subcarrier generators to the Stereo Pilot, lessening any tendency of the subcarrier to audibly interfere with the received program signal.

INSTALLATION OF THE FMX^{tm} SYSTEM OPTION

"Dummy Plug"

VERY IMPORTANT: Whenever the 706 is used *without* the option, a "dummy plug" *must* be kept in the accessory socket, J4, on the main Digital Board. This plug inhibits FMX^{tm} System ON / OFF logic and normalizes levels internal to the combining circuitry. The plug is installed with the arrow facing the Generator front panel.

Mounting

With the top cover of the Generator removed, the FMX^{tm} System plug-in circuit assembly is installed on the four threaded standoff spacers protruding from the Digital Board, directly above the power transformer.

Remove the "dummy plug" from the J4 accessory socket. J4 is a 16-pin DIP socket hiding just under the edge of the Analog Board. Remove the screws from the tops of the four spacers and secure the FMX^{tm} System circuit assembly in place with components facing up and the ribbon cable "pigtail" to the right. *NOTE: Silkscreened legend on the FMX^{tm} circuit assembly will be upside-down. (sorry!)*

Insert the ribbon cable connector into J4. Pin 1 of the connector and the striped side of the ribbon cable will be nearest the Generator front panel.

R84 Removal

It is *important* that the 270k-ohm resistor, R84, be *removed* from the FMX^{tm} plug-in circuit assembly when it is used in the Model 706. When the FMX^{tm} plug-in board is ordered for the 706, it should have this resistor snipped out. *Locate R84 and check to make sure that this has been done.*

This completes installation of the FMX^{tm} System into the 706 Generator. No additional calibration is required. Be sure to save the "dummy plug"; it can be stuck to the inside of the Generator top cover with masking tape. *REMEMBER: the "dummy plug" must be replaced in the J4 accessory socket whenever the FMX^{tm} System option card is removed!*

Section III

SETUP AND OPERATION

PANEL CONTROLS AND INDICATORS

A brief description of the various front-panel controls and indicators is given here. The user is encouraged to at least skim this section to verify that terminology used here agrees with his understanding.

If he has not already discovered this for himself, the reader is informed at this juncture that all the user controls are located on a sub-panel beneath the removable front cover. Also (and, again, at the risk of insulting the reader's intelligence), we are advised by previous experience to remind all users that all-but-one of the variable adjustments beneath the removable cover are multi-turn controls and require *fifteen to twenty complete rotations* to cover their total operating range. Moreover, they don't go: "click-click" when they reach the ends of their travel.

INPUT GAIN - LINE IN
(L and R METERING)

These two controls (at the far-right) adjust for different program levels applied to the Left and Right main LINE IN barrier strip terminals. The controls have a 15dB range and normalize gain for "full modulation" inputs between -15dBu and 0dBu, and between 0dBu and +15dBu, depending on the position of the input gain range jumpers described on Pages 10 and 11. Levels may be metered with the L and R buttons.

INPUT GAIN - AUX IN
(L and R METERING)

When the rear-panel unbalanced AUX IN inputs have been selected by jumpering, as described on Page 11, the main LINE IN is disabled and these Left and Right controls normalize gain for "full modulation" inputs from "TEST" jack outputs of the "popular" Processor/Generator combination unit. These controls have only a ±3dB range around the input level design center of +12dBu. Levels may be metered with the L and R buttons.

SUBCARRIERS 1, 2 and 3
(SUB 1, 2 and 3 METERING)

These control the *injection* levels of RDS or SCA subcarriers applied to the rear-panel SUBCARRIER IN jacks. The subcarrier injection level may be metered by depressing the SUB 1, SUB 2 or SUB 3 buttons, along with the 20dB GAIN (10% F.S.) button for the appropriate scale.

COMPOSITE - LEVEL
(MPX METERING)

This adjusts the *overall* Composite Output level of the Generator, as delivered to both COMPOS. OUT (A and B) jacks on the rear panel. This is a "master" output level control and does *not* affect the relationships (level ratios) between the Stereo Program, Stereo Pilot, SCA subcarriers, etc. MPX metering is taken *before* this control, so as always to relate to 100% modulation of the carrier, rather than to an absolute output level.

COMPOSITE - PILOT (PILOT METERING)

Controls the Stereo Pilot injection level, between 6% and 12% of the total Composite signal. By depressing the PILOT and 20dB GAIN (10% F.S.) buttons, the Pilot injection may be monitored on the lower meter scale.

COMPOSITE - EQ and PHC

These two controls provide EQualization and PHase Compensation of the Composite output signal. These adjustments can help compensate for response and phase linearity deficiencies in STLs or exciter input stages, or left as-adjusted at the factory for best theoretical stereo separation. A detailed adjustment procedure starts on Page 19.

COMPOSITE PROCESSING

This control permits up to 3dB peak clipping of the Stereo Program component (only) of the Composite output signal. The 19kHz Stereo Pilot and SCA/RDS subcarriers are combined *after* the multiplex stereo signal has been "processed." *Use this control judiciously!* Clipping produces harmonics which can crosstalk into SCAs or someone else's program. (See *IMPLICATIONS OF "COMPOSITE PROCESSING"* on Page 21.)

PRE-EMPH. ON / OFF (PRE-EMPH.. INDICATOR)

Either 75μs (North America) or 50μs (Europe) transmission preemphasis is normally imparted to program audio prior to transmission. Inputs via the main LINE IN barrier strip are routed through the preemphasis network which may assume either characteristic depending on its jumpering (see Page 11). *In normal operation, this switch is always left ON, and a green LED shows the function active.* Input signals via the jumper-selected AUX IN jacks are assumed preemphasized, and this switch has no effect.

FLTR. COMP. ON / OFF (FLTR. COMP. INDICATOR)

Patented overshoot compensation circuitry controls the natural and unavoidable property of all low-pass filters to cause output amplitude over-excursions, even when a complex input signal has been pre-limited to 100%-modulation values. A green FLTR. COMP. LED indicates circuit action. *The switch is normally left ON,* but can be turned OFF for testing or as otherwise necessary to modulate the transmitter in excess of 100%. Also, when this switch is OFF the COMPOSITE PROCESSOR is similarly, but separately, defeated.

MODE (MONO / STEREO) (MODE INDICATORS)

These momentary (spring-return) switches duplicate the Remote Control functions described earlier. The Generator may be operated in STEREO (normal, and "wake-up" mode), or in MONO with program derived from the LEFT channel, the RIGHT channel, or from the L + R SUM.

FMX^{tm} ON / OFF (FMX^{tm} INDICATOR)

When the FMX^{tm} plug-in-option is installed, this switch provides local ON and OFF switching of the function. (Remote control is also provided via the rear-panel barrier strip.) A green LED shows that the FMX^{tm} option is installed and operational. The FMX^{tm} quadrature subcarrier, S', may be monitored on the upper meter scale with the S' button.

PILOT ON / OFF
(PILOT INDICATOR)

This switch turns ON and OFF the 19kHz Stereo Pilot. *It is normally left ON,* but may be turned OFF for Composite EQ and PHC adjustments, and for other testing. A green LED indicates that Pilot is ON. *NOTE: The switch also controls the rear-panel 19kHz TTL-level output signal.*

POWER ON / OFF

Intuitive readers skilled in broadcasting technology will find that this switch requires no particular introduction. Others may write or call for specific instructions.

BARGRAPH METERING

The dual-channel bargraph meter is *peak*-responding, and is useful in level-setting and to verify proper operation of the 706 Generator. The upper and lower scales are associated with the upper and lower rows of selector pushbutton switches, respectively, which incorporate LEDs to indicate the parameter metered.

The far-right button in each row is a push-on, push-off "multiplier" which adds 20dB gain to the metering function. The meters thus cover 43dB in 1dB steps over two ranges: from +3dB to -20dB, and from -17dB to -40dB. An LED associated with the 20dB GAIN button indicates that the additional gain is switched in, and that the 0dB, 100% point on the scale refers instead to -20dB and 10%.

"0dB" generally refers to a level which corresponds to 100% modulation. Left and Right channel program inputs are normally set to this figure, and a 0dB Composite Output (MPX) reading should generally correspond to 100% carrier modulation. The 19kHz Stereo Pilot (PILOT) and additional subcarriers (SUB 1, SUB 2 and SUB 3) are metered with the additional 20dB gain switched in, and can be adjusted with respect to 10% carrier modulation.

INITIAL SETUP PROCEDURE

This setup procedure for the 706 Generator presupposes a simple installation with the Generator fed directly from the output of a properly adjusted Audio Processor. As explained on Pages 3 and 4, the Processor should maintain program peaks at a ceiling value corresponding to 100% modulation and incorporate "preemphasis protection" (independent high frequency) limiting in addition to broadband peak control.

The Procedure also assumes direct connection of the 706 output to the "composite" (broadband) input of the transmitter or exciter. Variations from these conditions, such as an intermediate STL (microwave link) in either the input or output path of the 706, may require considerations not addressed here.

1. Double-check PC board jumpering options for proper Line Input selection and level range, and (in the case of main LINE IN inputs) for proper preemphasis characteristic.
2. Set the MODE to STEREO; PILOT and FLTR. COMP. switches ON, FMX^{tm} OFF. If the Generator program input feed is via the main LINE IN input, turn the PRE-EMPH. switch ON. (This switch has no effect when the AUX IN inputs are used.)

3. Feed the *Audio Processor* Left channel input with a 500Hz sinewave test signal which yields 6 to 10dB of signal limiting. This should drive the Processor line output to its "ceiling" value and present the 706 Left input with a signal representing 100% modulation of that channel.

4. Press the L metering button and, while observing the bargraph display, adjust the L INPUT GAIN (LINE IN or AUX IN, depending on program feed) for a 0dB, 100% indication on the upper meter scale.

5. Shift the test tone to the Right input of the Audio Processor and verify the same amount of peak limiting as for the Left channel during Step 3.

6. Press the R metering button and adjust the R INPUT GAIN control for a 0dB, 100% indication on the lower meter scale.

7. Feed the Processor with a typical stereo program signal.

   A. The Audio Processor should indicate a normal amount of broadband peak and high frequency limiting.

   B. It is normal for the L and R bargraph display to indicate some overshoot beyond 0dB on active program material, even though the input level is held at an absolute ceiling value. This is due to phase response differences between Processor and Generator circuits. Overshoots should not frequently exceed +1dB.

   C. The green FLTR. COMP. indicator should flash on nearly all program peaks, indicating that internal compensation circuits are correcting for potential low-pass filter overshoots.

8. Turn the COMPOSITE PROCESSING adjustment fully counterclockwise to OFF. Observing the station Modulation Monitor, adjust the COMPOSITE LEVEL control for an indication of 100% modulation on program peaks.

   A. With either MPX button pressed, the bargraph meter should peak just under 0dB, or 100% modulation.

   B. The COMPOSITE PROCESSING control may be advanced, *at the user's discretion,* to gain a modest loudness advantage. (See *IMPLICATIONS OF "COMPOSITE PROCESSING"* on Page 21.)

9. Also with the aid of the Modulation Monitor, trim the COMPOSITE PILOT adjustment for the desired injection level; typically 8 - 10%. The injection level measured by the Modulation Monitor should agree with the lower bargraph display, when the PILOT and 20dB GAIN (10% F.S.) buttons are pressed.

10. Similarly, the injection levels of any SCA or RDS subcarriers may be adjusted at this time. If the Modulation Monitor has no provision for measuring these levels, the bargraph display may be used. Engage the 20dB GAIN (10% F.S.) multiplier and use the SUB 1, SUB 2 and SUB 3 buttons to reference the subcarrier injection level to full carrier modulation.

FMX^{tm} SYSTEM SETUP AND OPERATION

The following information should be understood before turning on the FMX^{tm} System.

The maximum FMX^{tm} quadrature subcarrier (S') signal level occurs when the L-R *input* signal is about 23dB below its usual 100%-modulation value (see Figure 1 on Page 5). With 14dB S' gain at this point, the *total* difference-signal modulation due to vector addition of the normal (S) and quadrature (S') sub-channels will be about 9dB below the 100%-modulation value. Since the FMX^{tm} System incorporates equalization in the S' channel, these levels will be correct only above 5kHz or so.

It is important to note that since FMX^{tm} signal compression is ultimately referenced to the Stereo Generator *output* level, adjustment of the COMPOSITE LEVEL (output) control of the 706 Generator or any subsequent gain control in the Composite signal path (STL or Exciter Input Gain) will change the maximum FMX^{tm} signal insertion level. MISADJUSTMENT OF THIS LEVEL BY MORE THAN ±1dB WILL ADVERSELY AFFECT TRANSMITTER MODULATION AND RECEIVER NOISE MODULATION ("breathing") REJECTION.

The following level check must therefore be performed, and readjustments possibly made, when operating the 706 Stereo Generator with the FMX^{tm} System installed and turned ON.

1. Make sure the FMX^{tm} switch is OFF and perform Steps 1 through 10 in the Initial Setup Procedure starting on Page 16
2. Apply the 500Hz test signal to both Left and Right Audio Processor inputs and verify that the INPUT GAIN controls are set for an L and R bargraph meter reading of 0dB, or 100%.
3. Turn the FLTR. COMP. switch OFF and observe the station Modulation Monitor. Total modulation (including the Stereo Pilot) should be exactly 100%. If this is *not* the case, readjust the COMPOSITE LEVEL control so that it is. This ensures that the FMX^{tm} signal compression will be properly referenced to total modulation.
4. Turn the FLTR. COMP. and FMX^{tm} switches ON.
5. Any further modulation adjustments should be made with the L and R INPUT GAIN controls. The COMPOSITE LEVEL should be changed only if *absolutely necessary*, and then by no more than ±1dB. Remember, adjusting the level of the Composite signal will change the FMX^{tm} signal insertion level from its optimum point

Since the FMX^{tm} System operates by compressing the difference channel, it is normal to note an increase in the L-R (subchannel) level as shown on most Modulation Monitors.

The FMX^{tm} System incorporates a subsonic identification tone which is transmitted in the quadrature subchannel. This tone is used to automatically signal and FMX^{tm} Stereo receiver to switch to the proper reception mode. Frequency of the ID tone is approximately 10Hz, and it modulates the main carrier at 1.0% of total modulation.

The FMX^{tm} ID level can be checked with most Modulation Monitors by selecting the "38kHz" function. The 38kHz filter in the Monitor should have sufficient bandwidth to just pass the 10Hz sidebands, while at the same time rejecting program material. Check the particular Owner's Manual to verify this. In any event, the ID level can be checked in the absence of program modulation with the "L-R" function of the Mod Monitor. Since the nominal insertion level is 1.0%, the "-40dB" scale should be used. Note that most Modulation Monitors change from PEAK reading to AVERAGE reading at this increased sensitivity. If this is indeed the case, the meter will read *4dB lower* than the actual modulation, indicating a proper ID level at -44dB.

For more information about the FMX^{tm} identification tone, see the Circuit Description section of this Manual.

COMPOSITE EQUALIZATION AND PHASE ADJUSTMENTS

Provision has been included in the 706 for comprehensive equalization of the Composite Output signal. The adjustments have been optimized at the factory for best stereo separation based on the "oscilloscope method" of measurement at the rear-panel COMPOS. OUT connector(s).

It is relatively easy, however, to readjust both the COMPOSITE EQ and PHC controls to correct for other transmission system frequency and phase response deficiencies, either in the exciter input stages, in a Composite STL, or even in a lenghty cable run between the Generator and the transmistter.

If the frequency and phase responses of the transmission system *beyond* the 706 are known to be linear, it's probably best to *leave the adjustments alone!* A procedure for trimming these adjustments is, nonetheless, outlined here.

1. Turn the PRE-EMPH, PILOT and FMX^{tm} switches OFF; otherwise, the Generator should be in the normal STEREO mode.

2. Feed a 1kHz sinewave test signal *directly* into the Left channel LINE IN of the Generator at a level which yields a -1dB indication on the upper bargraph display when the L button is depressed. *NOTE: It is important that there is no test signal leakage into the Right channel input of the Generator. If the signal is fed via the normal program audio chain (console, audio processing equipment, etc.), crosstalk in the program chain will result in improper adjustment.*

3. With an oscilloscope, monitor the *demodulated* Composite signal at the appropriate wideband output of the Modulation Monitor. A short length of coax should connect the Mod Monitor *directly* to the vertical input of the 'scope. Do *not* use a 'scope probe to monitor this signal, and be *sure* that the oscilloscope is known to be in proper calibration. Phase shift in the 'scope input circuitry will result in improper adjustment! It's best to externally trigger the 'scope timebase directly from the audio signal which feeds the Left channel input of the 706 to assure a more stable display of the demodulated composite waveform, which should resemble Figure 6 on the following page.

4. Increase oscilloscope vertical sensitivity to resolve "flatness" of the baseline. Be advised that some oscilloscopes will show erroneous distortion at the baseline when the vertical amplifier is severely overdriven. Watch for an *abrupt* change at the baseline as the vertical sensitivity is progressively increased; ie: a change in flatness which does *not* correspond to a step increase in the vertical gain. Keep gain below such an overload point.

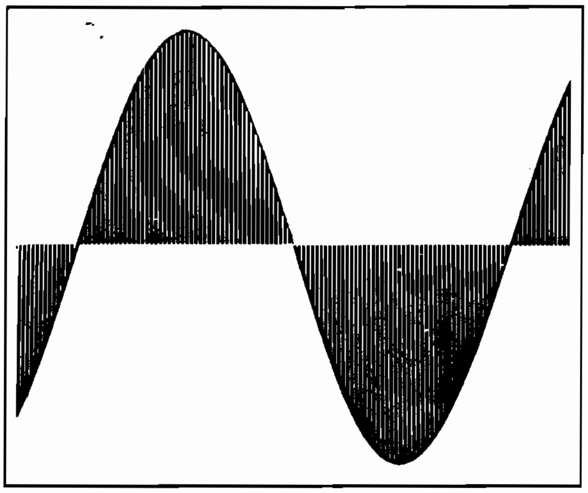


Figure 6 - Composite Output
(Left Channel Driven, Pilot OFF)

5. As the COMPOSITE EQ (EQualization) control is rotated from one extreme to the other, the observed baseline should pass through a point of optimum flatness in the "up and down" direction, as depicted in Figure 7a. Set the control for best flatness at the 1kHz test frequency.

6. Reset the sinewave test signal to 15kHz. Check that the upper bargraph still reads -1dB, and reset the 'scope timebase for a display similar to Figure 6.

7. Rotate the COMPOSITE PHC (PHase Compensation) control from one extreme to the other. The baseline should pass through a point of optimum flatness in a "side-to-side") direction as shown in Figure 7b. Set the control for best flatness at the 15kHz test frequency.

8. Reconnect the sinewave signal source to the Right channel LINE IN. Verify that the lower bargraph reads the same -1dB when the R button is depressed.

9. Repeat Steps 5, 6 and 7 for a Right channel feed. The observed waveforms should not differ from the Left channel tests, but "split the difference," as necessary, for best overall baseline flatness when either channel is driven.

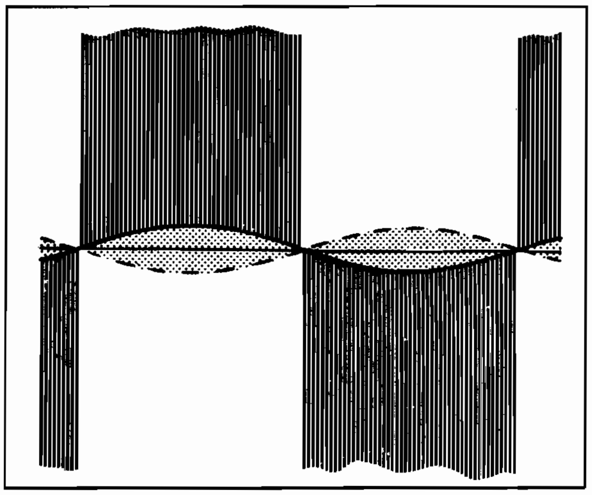


Figure 7a - COMPOSITE EQ Adjustment

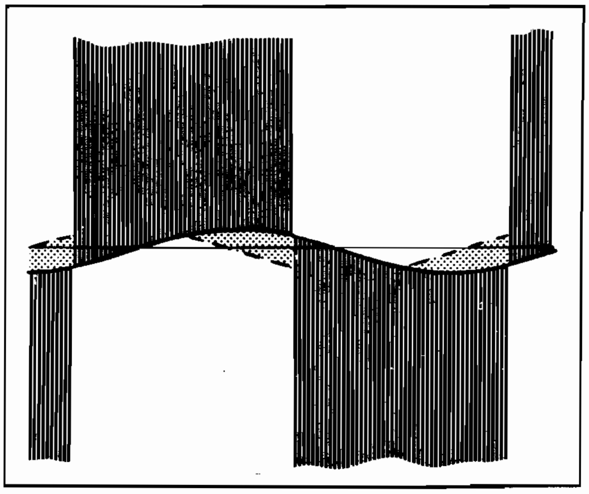


Figure 7b - COMPOSITE PHC Adjustment

FMX^{tm} SYSTEM PERFORMANCE CONSIDERATIONS

It is important to note that the maximum benefit from the FMX^{tm} System will be realized when all components of the broadcast chain are operating at their best performance. These components can be lumped into three categories: SOURCE, RELAY, and TRANSMISSION.

Source Components

Since the FMX^{tm} System is a noise-reduction system, source material with an inherently poor signal-to-noise ratio will limit the final endpoint signal quality. Well-kept vinyl records, noise-reduced tapes and Compact Discs will prove the best source material for high quality broadcasts.

Relay Components

Audio mixing boards with old amplifiers will no doubt degrade audio performance, as will any other poorly-operating line amplifiers, signal processors or STLs in use. Particular care should be exercised in the operation of a composite STL, since changes in gain, frequency response or phase response will affect the ultimate received program quality. This is also true when a repeater gets its off-air signal in composite form.

Transmission Components

The linearity of the transmitter power amplifier can have a great effect on FM transmission. Substantial non-linearity will distort the sidebands of the transmitted signal, compromising separation and introducing distortion. Linearity can easily be measured with an AM detector connected to a directional coupler on the transmission line to the antenna. With a 400Hz signal applied at 100% modulation, any incidental AM measured by this technique should be at least 50dB down from the carrier power. Inordinately high VSWR at the antenna will also degrade transmission performance, especially with a long transmission line run.

Recommended Reading

A general overview of the FMX^{tm} System, with particular emphasis on putting the System "on-air," is given in the paper: *Implementing FMX^{tm} At Your Station*, by Emil Torick of Broadcast Technology Partners. This paper was first presented at the NAB Engineering Conference in Las Vegas, Nevada on April 9, 1988.

A reprint of this paper is supplied by Inovonics with each Stereo Generator equipped with the FMX^{tm} System plug-in option, or upon request.

IMPLICATIONS OF "COMPOSITE PROCESSING"

In the FM "Loudness War," the ultimate tool in the broadcaster's arsenal is *composite processing*; more appropriately named *composite clipping*, since linear gain-reduction techniques cannot readily be applied to the "interleaved" multiplex stereo signal. The historic justification for composite clipping reflects the need to control the overshoots of uncorrected low-pass filters in early stereo generators.

Despite refinements in filter technology which all but eliminate overshoot as a potential overmodulation problem, it seems that a small gain in perceived loudness can always be achieved by clipping peak excursions of the multiplex signal just before it is fed to the exciter. This clipping action is not without certain tradeoffs, however, among which are modulation of the 19kHz Stereo Pilot and generation of out-of-band distortion components.

Pilot Modulation

The 19kHz Stereo Pilot, at a level already some 20dB below 100% modulation, is subject to amplitude modulation by program peaks when overall composite clipping is employed. With more than about 1dB of clipping, the pilot can actually be lost for the duration of the clipped peak. If the predominant program frequency is low, the receiver's stereo decoder may temporarily lose phase-lock.

Sophisticated stand-alone Composite Clipper devices strip the 19kHz Stereo Pilot from the composite signal, clip the remaining baseband/subcarrier components, then re-apply the pilot. The Inovonics 706 simply performs the clipping function prior to Stereo Pilot insertion.

Out-of-Band Components

Simple clipping of a symmetrical waveform will invariably generate odd-order harmonics of the fundamental frequency. The level of, and signal degradation by, these harmonics will depend in large part on the *depth* of the clipping action. In the case of FM broadcasting, clipping products can clutter that part of the spectrum reserved for SCA and RDS subcarriers, potentially creating crosstalk into those services. With a dB or two of clipping, distortion products will generally be tolerable; much more than this will not only compromise subcarrier services, but can interfere with next-adjacent stations as well.

Figures 8a through 8d reveal the out-of-band components generated by composite clipping. For these examples the output of a Proton AC-300 CD Player was connected directly to the Line Inputs of the 706 Generator. No processing was used, the Generator input gain was adjusted so that the internal clippers ahead of the low-pass filters were active about 90% of the time. The Generator output was fed to a Tektronics 7L5 Analyzer with the following settings: Center Frequency, 50kHz; Horizontal Dispersion, 10kHz/div.; Resolution Bandwidth, 1kHz; vertical display, 10dB/div.

Test material was a CD of Alphaville's *Forever Young*, the 6-minute "disco single" version. This was played in its entirety for each spectrum accumulation at various levels of (pre-pilot) Composite Clipping. The FMX^{tm} System was ON in all instances.

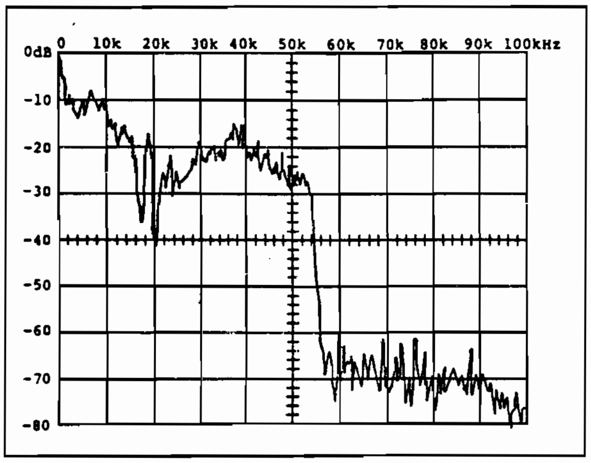


Figure 8a - Composite Clipper OFF

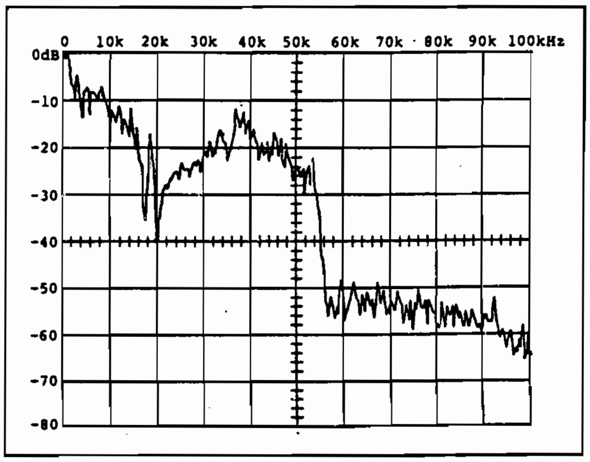


Figure 8b - 1dB Composite Clipping

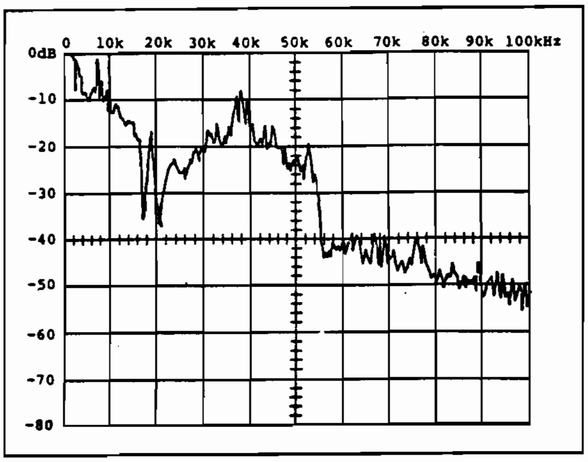


Figure 8c - 2dB Composite Clipping

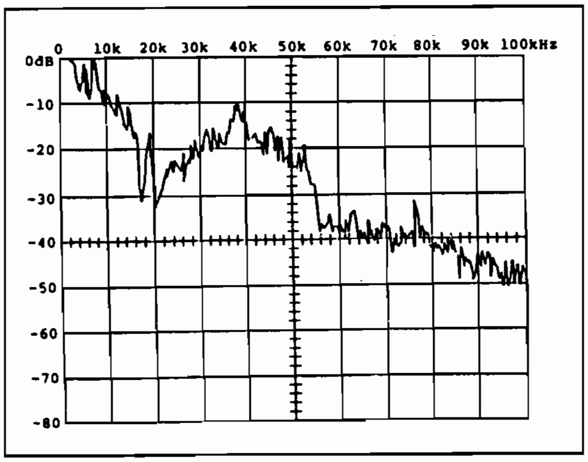


Figure 8d - 3dB Composite Clipping

Section IV

CALIBRATION

I. EQUIPMENT REQUIRED

A. Dual Trace Oscilloscope; 2mV sensitivity, 20MHz bandwidth; with two matched 10:1 probes.

B. Audio Generator; 10Hz - 1MHz, +20dBm output capability with step and vernier attenuators.

C. AC Voltmeter; "dBm" scaling, -60dB to +20dB measurement range.

D. Frequency Counter (Capable of accurate frequency measurement from 1kHz to 2MHz.)

E. Spectrum Analyzer (for optional Pilot Distortion Null calibration only); must have good resolution in the 100Hz - 100kHz display range.

II. PRESET AND POWER-UP

A. If the unit is equipped with the FMX^{tm} option, unplug the option board from J4. If J4 is fitted with an FMX^{tm} "Dummy Plug," *remove it at this time.*

B. Preset all trimpots as follows:

   1. All single-turn trimmers at mid-rotation, *except for R63 and R89,* which should be set fully counterclockwise.

   2. All front-panel multiturn trimmers should be set fully counterclockwise.

C. Apply power to the unit. Check with the 'scope for all five power supply voltages. The power diodes next to the five voltage regulators (on the bottom Digital board) make convenient test points. You should be able to find +9, -9, +15, -15 and +18 volts.

D. Press the POWER SUPPLY metering button. Adjust R89 (on the bottom Digital Board) for a reading of 0dB on the lower bargraph meter.

E. On the bottom Digital board, check pin 4 of IC23 for the 1.216Mhz clock. Observing the 'scope, turn power on and off a few times to make sure that the oscillator "starts" readily each time. Connect the 'scope probe to a counter and adjust C32 to set the frequency *exactly* to 1,216,000Hz.

III. INPUT CIRCUIT LEVEL CHECK AND SET

A. The unit should be jumpered for HIGH level, NORMAL Line Inputs (see Figures 3 and 4, Page 11.

B. Install the FMX^{tm} "Dummy Plug" in J4 of the bottom Digital board; *this remains installed until the FMX^{tm} option (if used) is calibrated.*

C. Turn the PRE-EMPH switch OFF and the FLTR. COMP switch ON. Apply a 1kHz, +10dBm oscillator signal to both the Left and the Right LINE IN (main) inputs, *in phase* (oscillator "hot" lead to both "+" input terminals, oscillator ground and both "-" terminals to ground).

D. With two probes and a dual trace 'scope, monitor the Left channel signal at the right-hand end of R28, the Right channel signal at the left-hand end of R8 (upper Analog board).

E. Advance the L (Left) and R (Right) INPUT GAIN / LINE IN controls for a well clipped waveform on each trace; approximately 8 volts p-p. Note the *exact* peak-to-peak level in each case.

F. Turn the FLTR. COMP switch OFF and reduce the LINE IN controls so that the two observed 1kHz sinewave signals have *precisely the same peak-to-peak amplitudes* as their previous clipped counterparts.

G. Press the L (Left) and R (Right) bargraph metering buttons. Adjust R78 and R84 (on the bottom Digital Board), respectively, to set the two meters at 0dB.

H. Temporarily disconnect the oscillator from the Right Channel LINE IN. Trim the oscillator output level, if necessary, so that the L bargraph again indicates exactly 0dB.

I. Press the L+R and L-R metering buttons. Adjust R79 and R85 (Digital board), respectively, so that both bargraphs read exactly -6dB.

J. Reconnect the oscillator so that both inputs are again fed in-phase.

IV. LOW-PASS FILTER ADJUSTMENT

A. With PRE-EMPH OFF, FLTR. COMP ON, and 1kHz from the oscillator feeding both inputs, monitor the Left and Right channels at R28 and R8 as previously. Set the oscillator output level for a near-maximum unclipped waveform.

B. Reset the oscillator frequency to 19,110Hz and trim R51 and R77 (upper Analog board) for nulls on the observed waveforms.

C. Reset the oscillator frequency to 21,780Hz and trim R2 and R22 (Analog board) for nulls.

D. Reset the oscillator frequency to 34,570Hz and trim R57 and R83 (Analog board) for nulls.

E. Proceed *directly* to the Filter Overshoot Compensation adjustments.

V. FILTER OVERSHOOT COMPENSATION ADJUSTMENTS

A. Reset the oscillator frequency to 100Hz, output amplitude to +10dBm. The Left and Right channel waveforms should be *just* at the threshold of clipping. Verify this by increasing the oscillator amplitude a bit, but return the oscillator to a +10dBm output.

B. Increase the oscillator output level to +20dBm. This should take the circuit into 10dB of clipping.

C. With the variable vertical attenuators *of the oscilloscope,* set each 'scope trace for exactly 3 divisions p-p.

D. Increase the oscillator frequency to approximately 3.4kHz, fine-tuning for maximum amplitude of the "double-hump" waveform shown in Figure 9 on the next page.

E. With R71 and R97 (Analog board), set the left-hand "humps" the same distance *inside* the 3-division window as the right-hand "humps" are *outside* it, as shown below.

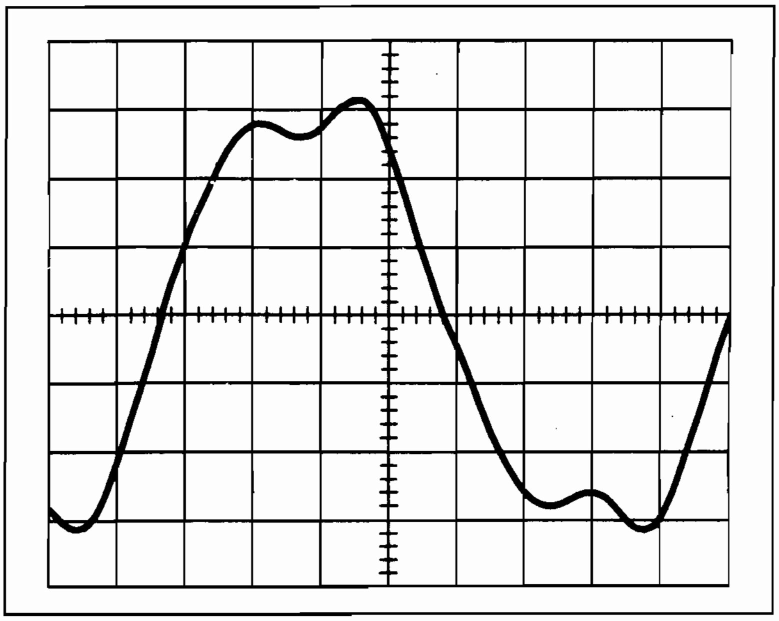


Figure 9 - Compensation Tuning (approx. 3.4kHz)

F. Increase the oscillator frequency to approximately 15kHz, fine-tuning for maximum p-p amplitude near cutoff. With R63 and R89 (Analog board), adjust this maximum amplitude to exactly 3 divisions p-p.

G. Reset the 'scope attenuators to the CAL positions. Run one of the COMPOS. OUTs *directly* into one vertical input of the 'scope. (Do not use a 'scope probe when the procedure calls for a *direct* connection.)

H. Apply 1kHz from the oscillator at +10dBm to both the Left and the Right channel main inputs, but this time *out of phase*. This requires that the oscillator "hot" lead be connected to the Left Channel "+" and the Right Channel "-" terminals, and the unconnected "-" and "+" terminals tied to ground along with the grounded side of the oscillator output.

I. With the Generator in the L+R SUM / MONO mode, and PILOT OFF, carefully trim one of the INPUT GAIN controls *and R71* (Analog board) *simultaneously* for a best signal null on the 'scope.

J. Increase the oscillator frequency to 15kHz and trim R57 (Analog board) for a best null.

K. Reset the oscillator frequency to 1kHz and increase its output amplitude to +20dBm. Adjust R63 (Analog board) for a best null of the cancelled overshoot products.

VI. OUTPUT LEVEL SET

A. In the L+R MONO mode, apply 1kHz from the oscillator to both the Left and Right channel main inputs, reconnecting for *in-phase* feed. (Oscillator "hot" to both "+" terminals; both "-" terminals and oscillator ground to ground.) Set the oscillator level for a +3dB indication on the L and R bargraph displays.

B. Monitoring the COMPOS. OUT *directly* with the 'scope, the observed sinewave should be well flattened on top and bottom. With the COMPOSITE / LEVEL control, adjust the observed waveform for 2.8 volts p-p.

C. Disconnect the oscillator signal and turn the PILOT switch ON. The Stereo Pilot waveform should be a fairly clean-looking sinewave. With the COMPOSITE / PILOT control, adjust the 19kHz Stereo Pilot to 0.3 volts p-p.

D. Reconnect the oscillator signal. The COMPOSITE / LEVEL control may be touched-up so that the combined audio and Pilot will have a total p-p amplitude of exactly 3 volts. Recheck the Stereo Pilot level (with oscillator disconnected) to verify a 0.3 volt p-p amplitude. Trim with the COMPOSITE / PILOT control if necessary.

E. At this point, and with both audio and Pilot at the proper levels, adjust R81 and R87 (on the bottom Digital Board) so that both bargraph displays read 0dB when the MPX buttons are depressed.

F. Again disconnect the oscillator. Depress the PILOT button and adjust R86 (on the bottom Digital Board) so that the lower bargraph reads -20dB. This should actually be set for a "zero" indication when 20dB GAIN button is engaged, but also verified at the -20 point with the display at normal gain. Similarly, when the MPX buttons are depressed, both displays should show the Stereo Pilot at -20dB, relative to full, 100% modulation.

VII. PILOT DISTORTION NULL (OPTIONAL)

A. Connect the COMPOS. OUT to the input of the Spectrum Analyzer. Set the Analyzer for a center frequency of 50kHz, 10kHz/div. dispersion, resolution bandwidth of 3kHz and vertical resolution at 10dB/div.

B. With the oscillator disconnected and only the Stereo Pilot present in the Composite Output, set the Analyzer gain so that the Pilot measures -20dB. Note any harmonics of the 19kHz signal. R76 and R77 (near the rear of the bottom Digital Board) may be used to null the odd and even harmonics, respectively. These control do interact somewhat, and must be adjusted carefully as a pair. Proper adjustment will maintain harmonics below a -70dB level, relative to 100% modulation.

C. Reconnect the 'scope to the COMPOS. OUT and check the Stereo Pilot level for its 0.3 volts p-p value and -20dB reading on the bargraphs display.

VIII. SCA / RDS LEVEL VERIFICATION

A. Connect the oscillator to SUBCARRIERS IN 1. Adjust the oscillator frequency to 80kHz, level to +10dBm.

B. Depress the two MPX buttons and engage both 20dB GAIN buttons. Adjust the INPUT GAIN / SUBCARRIERS 1 control for a bargraph indication of 0dB (actually -20dB). Depress the SUB 1 button, disengage the 20dB GAIN, and adjust R82 (on the bottom Digital Board) for a bargraph display of 0dB.

C. Repeat the above two steps for the numbers 2 and 3 Subcarrier Inputs, adjusting R88 and R83 (Digital board), respectively, for a 0dB indication on the SUB bargraph display, concurrent with a -20dB MPX indication.

FMX^{tm} PLUG-IN OPTION CALIBRATION

NOTE: This portion of the Calibration Procedure applies only to Generators which contain the FMX^{tm} System plug-in circuit assembly option card. Moreover, it is assumed that the Generator has been thoroughly calibrated in accordance with Section IV thus far and, especially, that the Generator output level is set as described on Page 26. *FMX^{tm} System circuit assemblies which are field-installed have been precalibrated at the factory and do not require this procedure when initially put into service.*

A. Connection and Presets:

1. With mains power OFF, remove the "Dummy Plug" from J4 of the Digital board and insert the ribbon cable from the FMX^{tm} circuit assembly. Refer to instructions on Page 13 if the circuit assembly was previously removed and requires re-installation.
2. Center all plug-in assembly trimpots, except for R39 which should be turned fully counterclockwise.
3. Reapply power, and with the 'scope probe check for a 10Hz, 15-volt p-p sinewave at TP9 of the plug-in assembly.
4. Turn the FMX^{tm} switch ON and PRE-EMPH switch OFF. The Generator should be in the STEREO mode.

B. Compressor Alignment

1. Connect the test oscillator *directly* to TP1 (TP1 and chassis ground) of the plug-in assembly. Monitor TP2 of the plug-in assembly with the AC Voltmeter (TP2 and chassis ground). Adjust the oscillator output level for a reading of -12dB on the voltmeter.
2. Shift the voltmeter monitor to from TP2 to TP3 and adjust R24 on the plug-in assembly for a meter reading of +1dB.
3. Reconnect the voltmeter to TP2 and adjust the oscillator output level for a meter reading of +10dB.
4. Move the voltmeter connection back to TP3 and adjust R9 on the plug-in assembly for a null (should be -55dB or so).
5. Reconnect the meter to TP2 and set the oscillator output level for a 0dB reading.
6. Again shift the voltmeter to TP3 and adjust R7 for a reading of -1.5dB.
7. Repeat the above sequence to verify proper meter readings at all three output adjustments of the oscillator. The three controls do interact, and it may be necessary to trim each one to obtain the proper measurements.

C. Filter Alignment

1. Temporarily ground the "CD" terminal of the plug-in circuit assembly with a clip lead to the chassis to defeat the FMX^{tm} System Compressor circuitry. Feed the oscillator to TP1, as before, and monitor TP5 with the 'scope probe. Set the oscillator frequency to 1kHz and adjust the oscillator output level for a 1.5-volt p-p waveform.
2. Raise the oscillator frequency to 19,110Hz and adjust R57 (plug-in circuit assembly) for a null.
3. Reset the oscillator frequency to 21,780Hz and adjust R63 (plug-in circuit assembly) for a null.

4. Reset the oscillator frequency to 34,570Hz and adjust R51 (plug-in circuit assembly) for a null.

5. Remove the ground strap from the "CD" terminal.

D. Overshoot Compensation Adjustment *(must directly follow previous Filter Alignment steps)*

1. Adjust R39 on the plug-in assembly for approximately the same DC resistance as R63 and R89 on the Generator's upper Analog board. This adjustment is not critical and can be made simply by setting R39 for the same relative angular position as the other two trimpots.

2. Disconnect the oscillator from TP1 and feed a 5kHz signal to the Left channel LINE IN (main) input of the 706 Generator (oscillator "hot" lead to "+" input terminal, oscillator ground and "-" terminal to ground).

3. With the 'scope Channel A probe, monitor the Left channel audio at the right-hand end of R28 on the upper Analog board. Clip the 'scope Channel B probe to TP5 on the plug-in assembly. Press the L-R bargraph meter button to show the "difference" signal level on the lower display, and the S' button for an FMX^{tm} subcarrier display on the upper bargraph.

4. Adjust the oscillator output level for a maximum amplitude waveform on 'scope Channel B, about 1.5 volts p-p. This should correspond with an L-R bargraph display of about -17dB. The waveform on Channel A of the 'scope should also be about 1.5 volts p-p, but out-of-phase with Channel B.

5. Adjust R80 on the lower Digital board for an S' bargraph reading of -9dB.

5. With the "ADD A & B" feature of the 'scope, and using both the 'scope variable attenuators and R32 on the plug-in circuit assembly, obtain a best null of the added signals.

6. Reset the oscillator frequency to 15kHz. Using the 'scope vernier attenuators and R51 on the plug-in assembly, obtain a best null.

E. FMX^{tm} ID Tone Set

1. Disconnect the oscillator from the Generator input and monitor the COMPOS. OUT *directly* with the 'scope.

2. Turn the PILOT switch OFF, but make sure the Generator is in the STEREO mode with FMX^{tm} turned ON. The COMPOSITE PROCESSING control should be turned fully counterclockwise.

3. With the COMPOSITE / LEVEL control calibrated per the *OUTPUT LEVEL SET* procedure on Page 26 (3-volts p-p for 100% modulation), observe the 10Hz DSB suppressed carrier signal present at the 706 output. Use R70 on the plug-in circuit assembly to adjust this ID tone to 0.03 volts (30 millivolts) p-p.

Section IV

CIRCUIT DESCRIPTIONS

PARTS LOCATION NOTE

Upon examining the various subassembly schematics, it will appear that component reference designations do not follow any particular order. This is because the parts, physically, are designated in a logical left-to-right, top-to-bottom sequence *on the circuit board*. This makes troubleshooting a bit easier since suspect components are more easily located after the schematic has been analyzed.

INPUT CIRCUITRY ("Analog" Board; Schematic - Page 45)

LINE IN Balancing Stage

IC18B is an "active-balancing" stage for the Left Channel main program line input. It affords rejection for common-mode signals, and the input network may be jumpered for either of two level ranges, as described on Pages 10-11.

High-Pass Filter

IC19B and IC20B comprise a 5-pole high-pass filter with a corner frequency of 20Hz and 30dB/octave low-end rolloff. This filter protects the 10Hz FMX^{tm} ID tone and prevents possible perturbations of transmitter exciter AFC loops by subaudible program signal components. Feedback for IC20B is taken from the LEFT LINE IN GAIN control for continuously variable adjustment of circuit gain over a 15dB range.

Preemphasis/ AUX Input

IC22B is a stage with unity gain for normal line inputs with Jumper J16 in the NORM position. When CMOS Analog Switch IC21D is turned on by the front panel PREEMPHASIS switch, R138 is bridged by either the parallel combination of C67 and C68, or the parallel combination of C66, C67 and C68, imparting 50μ-sec or 75μ-sec preemphasis, respectively, to the input signal.

Alternately, with Jumper J16 in the AUX position, the LEFT AUX INPUT is routed to IC22B, bypassing preemphasis and other input signal conditioning circuitry. Gain in this case is set at a value which matches the "Test Signal" preemphasized program output level of a popular combination Processor/Stereo Generator unit in wide use. R163 permits trimming the gain for "OPTImum MODulation."

Circuitry for the Right program channel is identical to that for the Left Channel just described. IC23 is a "sum-and-difference" matrix stage providing the L+R and L-R drives for bargraph metering.

FILTER OVERSHOOT COMPENSATOR ("Analog" Board; Schematic - Page 46)

Source of Overshoot

Any low-pass filter will exhibit a certain amount of "overshoot" and "ringing" at its output when presented with complex input waveforms. Generally, the sharper the cutoff the more pronounced the effect. Rather than a reflection on filter design, overshoots are attributable in large part to the expected and desired elimination of higher-order input signal components which, themselves, help define the amplitude limits. A 7-pole "elliptic" filter, such as is used in the 706, can exhibit overshoots in the order of 3dB or more, or 1.5 times the level of an amplitude-limited program input.

Unlike other systems of overshoot control which permit the filter to overshoot, then re-introduce the overshoots back into the signal path to mysteriously cancel themselves, the circuitry of the Inovonics 706 so conditions the amplitude-limited program signal that the filter, which is placed *after* the compensator, has little or no tendency to generate overshoots.

Input Clipper

CR6 and CR5 constitute a "hard" clipper at the compensator input, and are biased to a point which represents 100% modulation. Since this level is matched to the ceiling level of the final limiter in the audio processing system used *ahead* of the 706 Generator, the diodes rarely clip legitimate program waveshapes. The instead catch fast peaks which either have evaded the limiter, or may have been aggravated by phase shifts in the input and preemphasis stages.

Phase-Lag and Recombining

IC16A is a phase-*lag* circuit which time-displaces the fast leading and trailing edges of steep waveforms. Thus the primary characteristic of a program waveform which would normally *excite* filter overshoots is instead added to the waveform *amplitude*. CR4 and CR3, also biased to the 100%-modulation reference, "strip" these displaced-and-added components from the program signal. They are subsequently recovered by a differential amplifier IC14A which monitors the "stripper" input and output. These components, containing much of the program harmonic content, are recombined with the "stripped" program signal in summing stage IC13A, but in *opposite phase*. This 180-degree displacement of certain higher-order program harmonics is not discernable to the listener, but is quite effective in inhibiting filter overshoots.

DC Bias

The DC bias representing 100% modulation is derived from the +15V supply by voltage divider R146 and R147. CR11 is included to track and compensate temperature characteristics of the clipping diodes. IC24B buffers the +DC bias for positive peak clipping, and inverter IC24A provides -DC bias for negative peaks. When the front-panel FLTR COMP. switch is turned off, R148 is added to the divider string, increasing the reference voltage to a level which effectively biases the compensation circuitry out of operation.

FLTR. COMP. Indicator

IC25B is a differential amplifier which monitors the overshoot "stripper" recovery stage. Its output is rectified by Q3 and Q4 to turn on Q5 and flash the front-panel FLTR. COMP. indicator. C58 "stretches" the indicator ON time so that action on very fast peaks is adequately displayed.

LOW-PASS FILTER ("Analog" Board; Schematic - Page 47)

The 7-pole, elliptic-function (Cauer) low-pass filter is an active version of the classic L/C designs worked-out in Germany during the late 1940s - probably with a slide rule! The particular active configuration used here is frequently called the "FDNR" because each of the legs to ground simulates a *Frequency-Dependent Negative Resistance.* Referring back to the L/C design upon which this active circuit is based, the resistors in series with the signal directly replace series inductors, and each of the active circuits to ground replaces an inductor/capacitor series-resonant element.

For an in-depth discussion of this and other very useful filter circuits, the reader is directed to the "cookbook" consulted for this design: the *Electronic Filter Design Handbook* by Arthur B. Williams, published by McGraw-Hill. In his book the "FDNR" filter is called a "GIC," or *Generalized Impedance Converter*. Whatever!

IC3B buffers the output of the low-pass filter and provides gain to make up filter insertion loss. The signal level at the output of IC3B, corresponding to 100% modulation of the Left Channel is about 8V p-p.

SUBCARRIER AND PILOT GENERATION ("Digital" Board; Schematic - Page 50.)

Clock

IC23A is a crystal-controlled oscillator running at 1.216Mhz. All timing for the digital synthesis of the 19kHz Stereo Pilot, the 38kHz stereo difference subcarrier, and the 38kHz "quadrature" FMX^{tm} subcarrier is based on this master clock. This squarewave is buffered by the remaining sections of IC23 and divided to the 608kHz sampling frequency by IC17B.

Pilot Generation

IC18 is an up/down BCD counter clocked at the 608kHz sampling frequency. IC21, a 1-of-10 decoder, OR gate IC22A, and binary divider IC19A work together to keep IC18 continually counting from zero up to 8, then back down to zero. The decoded outputs of IC21 also feed a resistor network at the summing node of gain stage IC27A. Input currents are scaled to generate a repeating *negative* half of a segmented sinewave at the op-amp output. IC27B inverts this half-wave signal to create a mirror image *positive*-going sinewave component. Divider IC17A, also clocked by counter gating logic, controls two CMOS analog switches, IC28B and IC28A, to alternately switch between the negative and positive waveform components, thus forming the complete 19kHz Stereo Pilot sinewave comprising 32 discrete steps. IC28C performs the on/off switching function for the Pilot, and the segmented sinewave is buffered by IC32B. R76 and R77 permit introduction of gain offsets to null odd and even harmonics of the Pilot waveform, respectively.

Center-Sampling

IC35B, another analog switch section, is controlled directly by the 1.216MHz clock, turning on for one-half of one clock period precisely at the *center* of each stepped Pilot waveform sample. This charges C43 to the sample's voltage value, which is held by buffer stage IC32A until the next center-sample. Center-sampling eliminates integration of switching "spikes" and noise concurrent with leading and trailing edges of waveform steps each time IC21 decodes a new count.

TTL Pilot Output

The input of comparator IC26 translates the buffered Stereo Pilot waveform into a symmetrical 19kHz squarewave, in-phase with the Pilot component in the composite output of the 706 Generator. This is a 5-volt p-p, TTL-compatible output intended for synchronizing 57kHz RDS generators to the Stereo Pilot, thus reducing phase jitter between these signals and subsequent interference generation by receivers. CR27 jams the TTL output low when the Stereo Pilot is intentionally turned off.

Subcarrier Generation

The L-R "difference" component of the stereo composite signal is digitally synthesized in much the same manner as the Stereo Pilot; that is, by sinewave segmentation. The subcarrier, however, is generated by a sinusoidal *commutation* between the Left and Right stereo program channels.

Up/down counter IC24 is clocked at the 608kHz sampling frequency, decoded by IC29 and, with gating provided by IC22D and IC19B, continuously counts from zero up to 8, then back from 8 to zero. A pulse from IC15B presets the counter to zero

(Right Channel) when the Pilot is at the proper phase relationship, ensuring positive synchronization between Pilot and subcarrier.

The decoded count from IC29 sequentially turns on one of nine CMOS analog switches tied to a resistive divider string bridging the Left and Right program signals. Each tap of the divider is consecutively up/down sampled. The effective "wiper" of this commutator is buffered by IC34B, center-sampled by IC35D, and held between samples by C45 and buffer IC34A. The stereo multiplex signal thus consists of 16 discrete sinusoidally-weighted steps.

COMBINING AND OUTPUT FILTER CIRCUITRY ("Analog" Board; Schematic - Page 48)

Combining Amplifier

The Stereo Pilot, normal subcarrier and FMX^{tm} subcarrier signals are combined by current-summing stage IC4A. Insertion level of the Pilot is adjustable by front-panel PILOT LEVEL control R157, part of a divider which also includes a series resistance at the output of the preceding sample-and-hold stage. CR1 and CR2 are biased to the same DC level as clipping diodes in the filter overshoot control circuitry. This determines an absolute ceiling value for the "main and sub" components of the composite output signal. With the front-panel COMPOSITE PROCESSING control R155 fully counterclockwise, the previously-leveled program signal will not force CR1 and CR2 into conduction. As the control is advanced, as much as 3dB of Composite Clipping may be imparted. Note, however, that the signal is clipped *prior* to Pilot insertion; the Stereo Pilot is never subject to clipping-induced modulation.

Up to three SCA or RDS subcarrier inputs may also be combined at the input of IC4A. Each subcarrier may be independently adjusted and, like the Stereo Pilot, are not involved in the Composite Clipping process.

Output Low-Pass Filter

IC4A and ICs 5,6,7 and 8 comprise part of a 14th-order, quasi-Bessel-function, low-pass output filter. This filter has a nominal corner frequency of 100kHz and excellent phase linearity to maintain best stereo separation.

The split capacitive feedback around IC5A includes a variable resistance leg to ground. This COMPOSITE EQUALIZATION adjustment permits tailoring the response of the output filter to compensate for a certain amount of response deficiency in other equipment, such as exciter input circuitry or a Composite STL. IC5B is configured as an all-pass variable phase compensation stage. Like the previous stage, the COMPOSITE PHASE may be adjusted to correct for nonlinearities elsewhere in the system.

Output Stages

The Composite Output line-drive amplifiers are located on the "Digital" Board; the schematic appears on Page 51. Two identical stages provide a pair of isolated, low-impedance outputs with virtual "voltage-source" characteristics. With their discrete-transistor buffering, these outputs are capable of driving long coax lines or other complex loads without instability.

METERING SELECTION / RECTIFICATION ("Digital" Board; Schematic - Page 52)

Two identical display selector circuits route the various internal signal levels to companion peak-hold rectifiers, and ultimately to the two bargraph displays. Each of the two displays is associated with a corresponding row of six selector buttons. Each row of buttons is encoded to a 4-bit address by diode logic on the Key Encoder Board (schematic on Page 53).

Keyboard Encoding

4-bit button logic from the upper selector row is re-coded into a 3-bit, binary address by IC20. Q4, turned on when any button is pressed, "strobes" IC20 to latch the logic. The binary address is returned to the Key Encoder Board and decoded by a 1-of-8 CMOS analog multiplexer to light the indicator LED within the associated pushbutton.

Another analog multiplexer, IC25, routes the signal from the selected metering source to IC9B. The gain of this stage may be increased by 20dB to extend the metering range. Analog gate IC14A is toggled on and off by logic from IC16A, controlled by the front-panel 20dB GAIN button in the upper row of metering selector buttons. IC16A also lights the LED within the 20dB GAIN button through Q2.

Peak Rectifier

ICs 12A, 12B and 11A comprise a full-wave rectifier, charging C14 to the instantaneous *peak value* of the signal to be metered. IC11B responds to the charging current through C14, its output going negative each time C14 charges to a higher peak value. This, in turn, charges C18 which, with IC10B, provides a "one-shot" function to hold the charge on C14 constant for about 100 milliseconds. When C18 finally "runs down," IC6B toggles to its normal negative output state and permits C14 to discharge through R11. Thus even the fastest transient peaks are held for a visually adequate display of their actual value.

The lower row of meter selection buttons operates with circuitry identical to that just described. The only difference is display of proper power supply operation, wherein the four primary regulated supplies are summed through R108-R111 to drive the lower bargraph meter to a "Zero-dB" reference level.

BARGRAPH DISPLAY CIRCUITRY (Display Board; Schematic - Page 54)

Each of the two front-panel bargraph displays is contained on independent, identical circuit assemblies. The selected and peak-rectified DC voltages are routed to the Display Boards via a ribbon cable, and jumpering on each Display Board determines which of the two selections is displayed. The upper board has position #1 of J2 jumpered; the lower board, position #2.

Log Conversion

Linear-to-log conversion utilizes a digital counter circuit and the precise logarithmic discharge of a capacitor through a fixed resistance. IC5B and IC5C are configured as an astable multivibrator free-running at approximately 300Hz. IC6B buffers this and clocks binary counter IC3.

Counter Logic

Assuming a reset state, IC3 counts from zero upward. At count 52, IC8A is clocked with the Q3 output of IC3, having been "loaded" with the Q5 and Q6 outputs through IC5A and IC5D. With the next clock pulse IC8B is clocked, resetting IC3 and all other logic. The reset pulse also charges C3 through Q7 to a DC value set by R16 and regulator IC10. Following the reset pulse, IC3 again begins its count, and C3 begins a log-discharge "ramp" toward ground through R15.

The rectified signal input to the Display Board is presented to one input of comparator IC9, the log ramp to the other input. When the log ramp falls to the DC level to be displayed, the output of IC9 toggles high, setting IC7B. IC7A is clocked by either the next clock pulse following the comparator toggle, or by the counter reaching count 48 - whichever comes first. IC7A strobes IC4, a 6-bit clocked flip-flop, to load the count into the display driver circuit. IC4 holds this count until the entire counting/ramping process is repeated and a new count is transferred.

Display Decoder/Driver

Six groups of series-connected LEDs comprise the 48 element bargraph display. The "bottom" group (I2-I10) contains nine LEDs, the "top" group (I43-I48) has seven; each of the remaining groups contains eight. Each group is connected between a constant-current source transistor and ground, and a CMOS 1-of-8 analog multiplexer selectively grounds the LED junctions to extinguish LEDs "from-the-top-down."

Assuming that a count of 19 has been latched into IC4, outputs Q0, Q1 and Q4 would be high. Without any other logic, the highs on Q0 and Q1 would cause each of the 6 multiplexers (IC11-IC16) to ground the X3 output, extinguishing the top three LEDs in the "top" group, and the top four LEDs in each of the seven other groups. However, the INH (inhibit) inputs to these multiplexers are normally held high, preventing any LEDs from being grounded-out.

The high on Q4 from IC4 causes multiplexer IC2 to ground its X2 output and, through diode CR10, the X1 output is grounded as well. This does two things. First, the INH inputs of both IC14 and IC15 are grounded which enables both of these multiplexers to perform their selective grounding function, and buffer IC1 shunts *all* the LED current from Q1 and Q2 to ground. This means that for a count of 19 the top two groups of LEDs are all off as well as the top four LEDs in the third group. All the rest, down to the bottom of the display, are on. This would indicate a "-6dB" on the bargraph display. The count latched into IC4 *extinguishes* a like number of LEDs from the top of the display, and the count is "inversely log-proportional" to the display input voltage.

REMOTE FUNCTION CONTROL ("Digital" Board; Schematic - Page 51)

The six remote control inputs are each decoupled with an R/C network for RFI and noise suppression, and applied to the inverting inputs of six op-amp comparators. A ground on any remote control line will drive the comparator output high, and a series of "steering" diodes performs an OR function with the "center-off" panel switches.

MONO/STEREO Switching

CR39 and CR40 encode the three possible MONO selections into 2-bit binary for latch IC39. Q10 saturates with any MONO or STEREO command to pulse IC39 and latch the MONO coding (or "all zeros" if STEREO is chosen). Latched binary logic from IC39 is decoded back into 1-of-4 logic by IC42A. IC43A, IC43B and associated driver transistors illuminate the front-panel MONO LEFT and MONO RIGHT indicators (or both) to show which channels constitute the monaural output.

Referring to the schematic for the multiplexer circuitry on Page 50, a LEFT MONO command drives "jam" input D and the "carry-in" of IC24 high, presetting and stopping the counter. This is decoded by IC29 to route Left Channel audio exclusively through IC35C to the output. An L+R MONO command similarly stops the counter with a C "jam" input; this is decoded by IC29 to sample the mid-point of the resistive divider through IC36B. A RIGHT MONO command stops the counter with no "jam" address, causing a reset to zero and a Right Channel sample through IC37C. When incoming control logic is restored to "all zeros" IC24 resumes its normal commutation.

Pilot and FMX^tm Switching

IC28C turns the 19kHz Stereo Pilot on and off. Going back to the schematic on Page 51, STEREO operation enables the Pilot with a logic-high from the D0 output of IC42A. This logic also enables FMX^tm System operation through IC40A, the FMX^tm ON/OFF logic coming from set/reset flip-flop IC44A controlled by local and remote commands derived identically to MONO/STEREO switching functions previously described.

C58 and C51 provide a "power-on reset" pulse to preset all switching logic to the normal "wake-up" state with STEREO and FMX^tm ON.

POWER SUPPLY ("Digital" Board; Schematic - Page 49)

The Stereo Generator utilizes five separate regulated power supplies: bipolar 15 volts for most analog audio circuitry, bipolar 8 volts for CMOS digital circuits, and positive 18 volts for the bargraph displays.

The five supplies are regulated by linear "three terminal" IC voltage regulators fed from one bipolar "raw" supply. The single power transformer has dual primaries which may be switched in parallel or in series for 115-volt or 230-volt operation, respectively.

FMX^tm SYSTEM OPTION (Schematics - Pages 55 and 56.)

The "Santana" Circuit

The FMX^tm System Compressor uses two J-FETs in a feedforward configuration based on the "Santana" FET gain-control circuit. This circuit, originally described by Henry Santana of Hewlett-Packard Corp., is capable of voltage-linear gain reduction at levels considerably above those normally tolerated by traditional FET attenuators.

In the original circuit two matched FETs are employed; a "control" FET between the inverting input of an op-amp gain stage and ground, and a matching "dummy" FET from the non-inverting input to ground. This second FET is biased fully "on" and also is presented with the input signal through an identical input resistor. The "dummy" FET compensates for channel nonlinearities and temperature characteristics of the "control" FET for nearly perfect voltage-variable resistor performance.

"Reentrant" Compressor

In Inovonics' FMX^tm System Compressor variation, Q1 and Q2 are the "control" and "dummy" FETs, respectively. Left and Right program signals from the preemphasis stages are summed by IC1B to derive an R-L program *difference* signal. This is fed to the Santana circuit and to a "precision" full-wave rectifier. IC2A and IC2B deliver complementary-phase difference signals to rectifiers CR3 and CR4. CR1 and CR2 are included to compensate for the forward drop of the rectifier diodes.

The Compressor's complex attack and release timing requirements, as called out in the FMX^tm System Specification, are satisfied by a diode/resistor biasing network. For very small changes in the Compressor input level, a 2-second "leak" attack/release timing is afforded by the charge and discharge of C3 through R19. Larger changes in level call CR5 and CR6 into play, ultimately yielding a 1.5ms attack and 200ms release, respectively. The net effect is on of "the farther you go, the faster you get there," thus combining rapid Compressor action with very low self-modulation distortion of steady-state signals.

The difference-derived negative potential across C2 is buffered by IC3B and summed with a positive DC reference from CR9. This makes the output of IC4B a fixed *negative* voltage which is driven *positive* by the rectified difference signal. IC4A is an active clamp to keep the output of IC4B from ever going positive, even as the difference signal continues to increase. R24 scales the control DC to the pinchoff value of the particular FETs used and establishes the Compression Threshold. A small amount of compressed audio is fed through R25 and summed with the DC control voltage to further linearize the Santana circuit for reduced program signal distortion.

Transfer characteristics of this feedforward circuit would be more abrupt than the specified *reentrant* function (see Figure 1, Page 5) were it not for the R7/R8 series component at the Santana input. By adjusting R24 and R7, both the Threshold and the shape of the reentrant curve can be fit to specified parameters. R9 is a balancing control trimmed for maximum attenuation when Q1 is fully on (S' shutoff).

A level of +10dBu at the Compressor input (TP2) represents 100% L-R modulation. IC1A has a 14dB offset between the S and the S' signals. The Compressor output (TP3) is also scaled for a +10dBu equivalent of 100% L-R modulation, but S' reaches a maximum level of only +1.5dBu at this point due to the reentrant characteristic. The +1.5dBu is a bit short of the +2dBu output (8dB below 100% modulation) called for in the Specification; this is due to the "soft knee" feedforward transfer function which has the S' signal slightly into compression at the nominal Threshold value.

Low-Pass Filter

The FMX^{tm} System Specification calls for a "hard" peak clipper set a few dB above the output ceiling of the Compressor. This requirement is met by CR10 and CR11, the input clipper of the filter overshoot compensator. The S' compensator and filter circuits are identical to those in the Left and Right program channels which were discussed on Pages 30-32.

10HZ ID Tone

The 10Hz FMX^{tm} ID signal is derived from the 1.216MHz master clock. Programmable divider IC24 divides the clock by 20,480 for an output of 60Hz. IC18B, IC22 and IC23 reduce this to 10Hz and 30Hz symmetrical squarewaves which are combined with phase and amplitude relationships to effectively subtract the 30Hz third harmonic from the 10Hz signal. IC11A is a simple 3-pole low-pass filter which then furnishes a quite pure 10Hz sinewave.

S' Subcarrier Generation

The 10Hz ID signal is combined with S' at the input of IC13A. The output of this stage feeds one end of the S' subcarrier sine-sampling resistor string, and an inverted S' signal from IC13B feeds the other end. The string is commutated by a series of CMOS analog transmission gates controlled by a pair of shift registers, IC16 and IC17. IC18, IC19 and assorted gates provide synchronization with the multiplex circuitry on the main "Digital" Board. The sine-sampled output is center-sampled and combined with the normal 38kHz subcarrier and the 19kHz Stereo Pilot.

Section VI

APPENDIX

The following section of this Manual contains Parts Lists for the Model 706 Stereo Generator Subassemblies, Schematic Diagrams of all Generator Circuitry, and an explanation of Inovonics' Warranty Policy.

PARTS LISTS

EXPLANATION OF PARTS LISTINGS

The following pages contain listings of component parts used in the Model 706 FM / FMX^{tm} Stereo Generator.

The first parts listings are those components which are "peculiar" to individual circuit assemblies, or which require more than a "generic" description. These are listed by schematic component reference designation under each assembly heading. This is the *first* place to look for a parts description and ordering callout.

If the component in question is *not* listed under its subassembly heading, it is probably considered a "generic" part, common enough to most of the 706 circuitry to be lumped into a single category. These components are referred-to by physical description and value rather than by reference designation. The "GENERIC PARTS" section follows the individual subassembly listings.

Components which are *not listed at all* are probably not considered typical replacement parts. Should it become necessary to specify an unlisted part, a call to the factory with a brief description should straighten the matter out.

"ANALOG" CIRCUIT ASSEMBLY

C1,2,5,17-19, 30-33,36,38-42, 53-55,66-68	Capacitor, "High-Q," .0033µF, 2.5%, 100V; WIMA FKP-2 (Polypropolyne) or WIMA FKC-2 (Polycarbonate) preferred, any equivalent must have identical characteristics.
C6,20	Capacitor, Electrolytic, radial leads, 4.7µF, 25 VDC; Elna RE-series or equiv.
C7,21	Capacitor, Electrolytic, radial leads, 220µF, 6.3 VDC; Elna RE-series or equiv.
CR1,2	Diode, Schottky; 1N5711 or equiv.
IC1,2,9-20,22-25	Integrated Cct.; (open mfgr.) LF353N
IC3	Integrated Cct.; (open mfgr.) RC4458NB
IC4-8	Integrated Cct.; (Motorola) MC34082P
IC21	Integrated Cct.; (open mfgr.) CD4066BE
J1-3	BNC Connector, PC-mount; Switchcraft BNC-RAPC-3000
J4,5	"Phono Jack" Connector, PC-mount; Mouser 16PJ097
J6	Barrier Strip, 6-Terminal; Magnum A-204106-NL-R-50
---	Shunt, Jumpering-Selection; Robinson Nugent HPS-02-G
Q1-4	Transistor, NPN; (open mfgr.) 2N3904
Q5	Transistor, PNP; (open mfgr.) 2N3906
R155	Potentiometer, 5K "Thumbwheel"; Piher PT-15-YB
---	Interconnect Cable; "Analog" Board to main 706 circuit board (2 used), *Inovonics Part No.* 182104.

CHECK "GENERIC" SECTION FOR PARTS NOT LISTED ABOVE

"DIGITAL" CIRCUIT ASSEMBLY

C1,2	Capacitor, Disc Ceramic, (open mfgr.); .005μF, 1kV
C20,21	Capacitor, Electrolytic, radial leads, 6800μF, 35 VDC; Elna RE-series or equiv.
C32	Capacitor, Variable, 5-50pF; Mouser 24AA024
	Integrated Cct.; (open mfgr.) CD4053BE
C57	Capacitor, Electrolytic, radial leads, 100μF, 25 VDC; Elna RE-series or equiv.
CR1-5,17-20	Diode, Silicon Rectifier; (open mfgr.) 1N4005
CR11,23	Diode, Zener, 6.2-volt, 5%; 1N4735A or equiv.
F1	Fuseholder, PC-mount; Littlefuse 345-101-010
IC1,2	Integrated Cct.; (open mfgr.) LM337-T
IC3-5	Integrated Cct.; (open mfgr.) LM317-T
IC6-12,27,31-34	Integrated Cct.; (Motorola) MC34082P
IC13,20,39	Integrated Cct.; (open mfgr.) CMOS 4042BE
IC14,28,35-37	Integrated Cct.; (open mfgr.) CMOS 4066BE
IC15	Integrated Cct.; (open mfgr.) CMOS 4081BE
IC16,17,19,44	Integrated Cct.; (open mfgr.) CMOS 4013BCN
IC18,24	Integrated Cct.; (open mfgr.) CMOS 4029BE
IC21,29	Integrated Cct.; (open mfgr.) CMOS 4028BE
IC22,43	Integrated Cct.; (open mfgr.) CMOS 4071BE
IC23,40	Integrated Cct.; (open mfgr.) CMOS 4011BE
IC25,30	Integrated Cct.; (open mfgr.) CMOS 4051BE
IC26	Integrated Cct.; (open mfgr.) LM311N
IC38,41	Integrated Cct.; (open mfgr.) LM324N
IC42	Integrated Cct.; (open mfgr.) CMOS 4052BE
J1	Connector, AC Mains, PC-mount; Switchcraft EAC-303
J7-9	BNC Connector, PC-mount; Switchcraft BNC-RAPC-3000
J10	Barrier Strip, 8-Terminal; Magnum A-204208-NL-R-50
- - -	Connector, TO-220 Regulator Socket; Molex 10-18-2031
Q1,4,9-13	Transistor, NPN; (open mfgr.) 2N3904
Q2,3	Transistor, PNP; (open mfgr.) 2N3906
Q5,6	Transistor, NPN Power; (open mfgr.) MJE340
Q7,8	Transistor, PNP Power; (open mfgr.) MJE350
S1	Switch, DPDT Voltage Selector; C&K V202-12-MS-02-QA
S2	Switch, DPDT Slide; CW Industries GI-152-0001
S3,7,8	Switch, 2-Pos. SPDT Toggle, PC-mount; Mouser 10TF130
S4-6	Switch, 3-Pos. SPDT Momentary Toggle, PC-mount; Mouser 10TF145
T1	Power Transformer, PC-mount; Signal LP 40-600
Y1	Crystal, 1216kHz; *SPECIAL - Inovonics Part No. 1242*

CHECK "GENERIC" SECTION FOR PARTS NOT LISTED ABOVE

DISPLAY CIRCUIT ASSEMBLY

I1-10,11-20,21-30, 31-40,41-50	LED Bargraph Display, 10-Segment High-Efficiency Red; Lite-On LTA-1000E
IC1	Integrated Cct.; (National or SGS *only*) CMOS 4503BE
IC2,11,12,13,14,15,16	Integrated Cct.; (open mfgr.) CMOS 4051BE

(continued next page)

IC3	Integrated Cct.; (open mfgr.) CMOS 4024BE
IC4	Integrated Cct.; (open mfgr.) CMOS 40174BE
IC5,6	Integrated Cct.; (open mfgr.) CMOS 4011BE
IC7,8	Integrated Cct.; (National *only*) CD4013BCN
IC9	Integrated Cct.; (open mfgr.) LM311N
IC10	Integrated Cct.; (National) LM317LZ
Q1-7	Transistor, PNP; (open mfgr.) 2N3906
- - -	Shunt, Jumpering-Selection; Robinson Nugent HPS-02-G
- - -	Interconnect Cable; Display Boards to main 706 circuit board, *Inovonics Part No.* 182103.

CHECK "GENERIC" SECTION FOR PARTS NOT LISTED ABOVE

KEYBOARD CIRCUIT ASSEMBLY

I1,2	LED Indicator, Diffused Pastel Green, T-1 package; Stanley MPG 3878S
I3-6	LED Indicator, Diffused Pastel Red, T-1 package; Stanley MVR 3878S
IC1,2	Integrated Cct.; (open mfgr.) CD4051BE
S1-14	Switch, Illuminated Pushbutton; consists of one each ITW part no. 39-22100 (Switch Body), 80-390103 (Cap), 80-390100 (Light Pipette), 80-390003 (LED Support) and one red LED same as I3-6.
- - -	Interconnect Cable; Keyboard to main 706 circuit board, *Inovonics Part No. 182102.*

CHECK "GENERIC" SECTION FOR PARTS NOT LISTED ABOVE

FMX^tm PLUG-IN OPTION CIRCUIT ASSEMBLY

C1	Capacitor, Electrolytic, radial leads, 22μF, 25 VDC; Elna RE-series.
C6-12,14	Capacitor, "High-Q," .0033μF, 2.5%, 100V; WIMA FKP-2 (Polypropolyne) or WIMA FKC-2 (Polycarbonate) preferred, any equivalent must have identical characteristics.
C13	Capacitor, Electrolytic, radial leads, 4.7μF, 25 VDC; Elna RE-series.
CR9	Diode, Zener, 6.2-volt, 5%; 1N4735A or equiv.
IC1-3,5,6,8-11,13	Integrated Cct.; (open mfgr.) LF353N
IC4,7	Integrated Cct.; (Raytheon, T.I.) RC4558NB
IC12,14,15	Integrated Cct.; (open mfgr.) CMOS 4066BE
IC16,17	Integrated Cct.; (open mfgr.) CMOS 40194BE
IC18,19,22,23	Integrated Cct.; (open mfgr.) CMOS 4013BE
IC20	Integrated Cct.; (open mfgr.) CMOS 4081BE
IC21	Integrated Cct.; (open mfgr.) CMOS 4071BE
IC24	Integrated Cct.; (Harris, SGS) CMOS 4059AE
Q1,2	Transistor, N-Chan JFET; (Siliconix) J111 *SPECIAL MATCHED PAIR - Inovonics Part No. 1234*
- - -	Interconnect Cable; FMX^tm System plug-in option board to 706 main circuit board, *Inovonics Part No. 182101.*

CHECK "GENERIC" SECTION FOR PARTS NOT LISTED ABOVE

LISTING OF "GENERIC" COMPONENT PARTS FOR ALL ASSEMBLIES

This classification identifies all components which were *not* listed under individual subassembly headings. Grouped here are those components which are used "universally," and which were chosen, in part, for their ready availability. In searching for a particular component description (to order a replacement, etc.), look *first* under the proper subassembly heading. If the part is *not* found there, check the following listings.

UNLESS OTHERWISE SPECIFIED:

Capacitors:

a: **Under 100pf** are "dipped mica" type, DM-15 (or CM-05 military series) size designation; "P" value is picofarads, ±5%, 200 working volts, typical. Manufacturer open.

b: **100pf to .47μF** are of the metalized mylar or polyester variety; whole number "P" values are picofarads, decimal values are microfarads, ±5%, working voltage of 50 volts or more. The style used in 706 circuitry is the "minibox" package with a lead spacing of 0.2 inches. **Preferred mfgr.:** WIMA, MKS-2 or FKS-2 series. **Alternates:** CSF-Thompson IRD series; Panasonic ECQ-V series (Panasonic values above 0.1μF require lead forming).

c: **2.2μF caps** used throughout for power supply rail bypassing, etc. are 50-volt, high reliability radial-lead electrolytic. **Preferred mfgr:** Illinois Capacitor 225 RMR 050M.

Diodes, other than rectifier, Zener and Schottky diodes, are general-purpose, small-signal silicon diodes of low leakage, and with a breakdown voltage of at least 50 volts. **Preferred part:** 1N4151. **Alternates:** 1N4148, 1N914, etc. in DO-7 or DO-35 package.

Resistors:

a: **Fixed resistors** with no tolerance specified are ¼-Watt, 5%, carbon-film type; with 1% tolerance specified are ¼-Watt, 1% metal-film type. Values are in ohms; manufacturer open.

b: **Multi-Turn Trimming Potentiometers** are Beckman 89PR series or equivalent "cermet" type.

c: **Single-Turn Trimmers** are Beckman 91AR series.

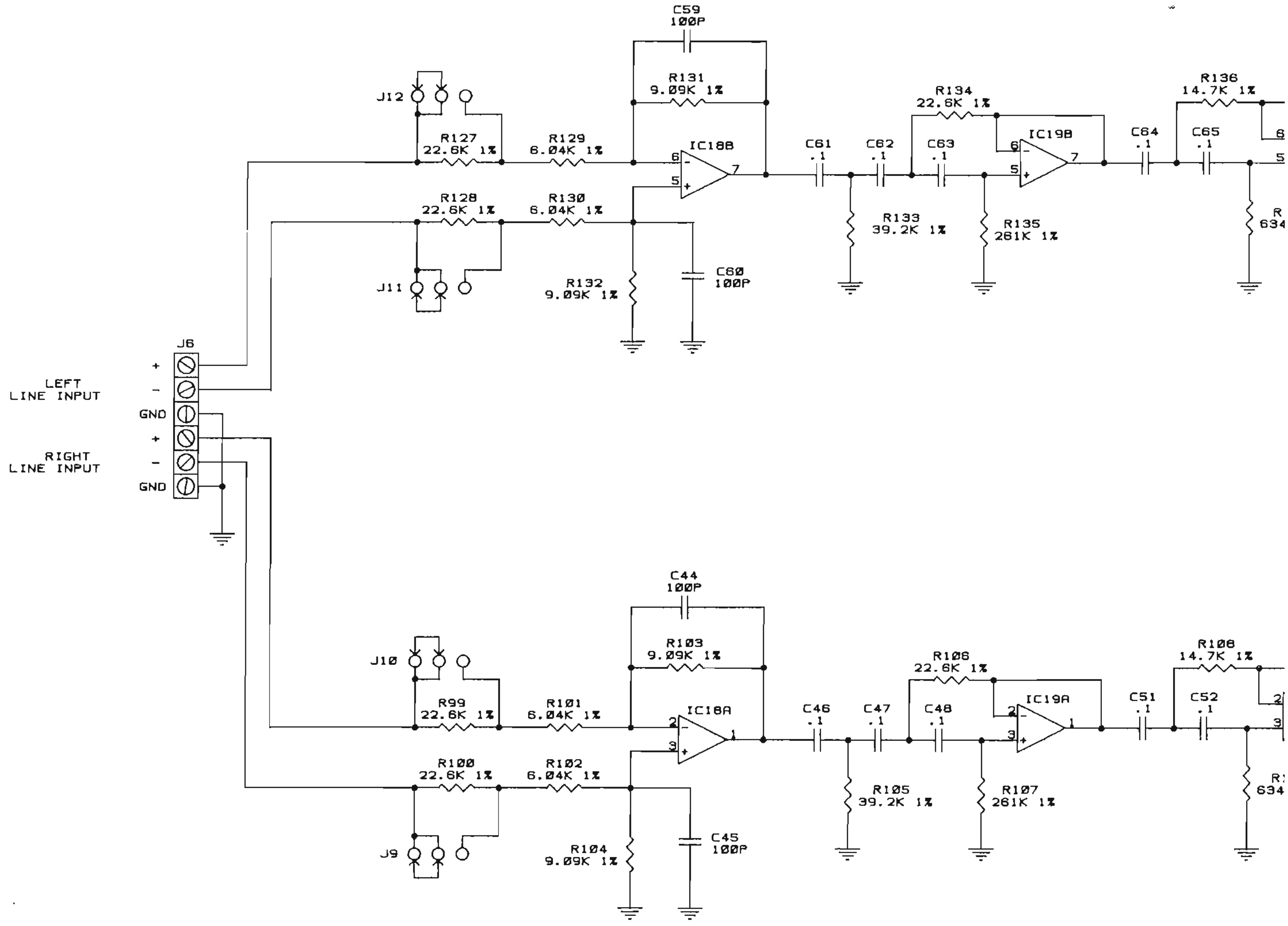
MAIL-ORDER COMPONENT SUPPLIERS

The following electronic component distributors are reputable suppliers of both large and small quantities of parts. Any semiconductor, IC, capacitor, resistor, or connector used in the Model 706 is available from one or more of these firms. Each of these suppliers publishes a full-line catalog, available free of charge.

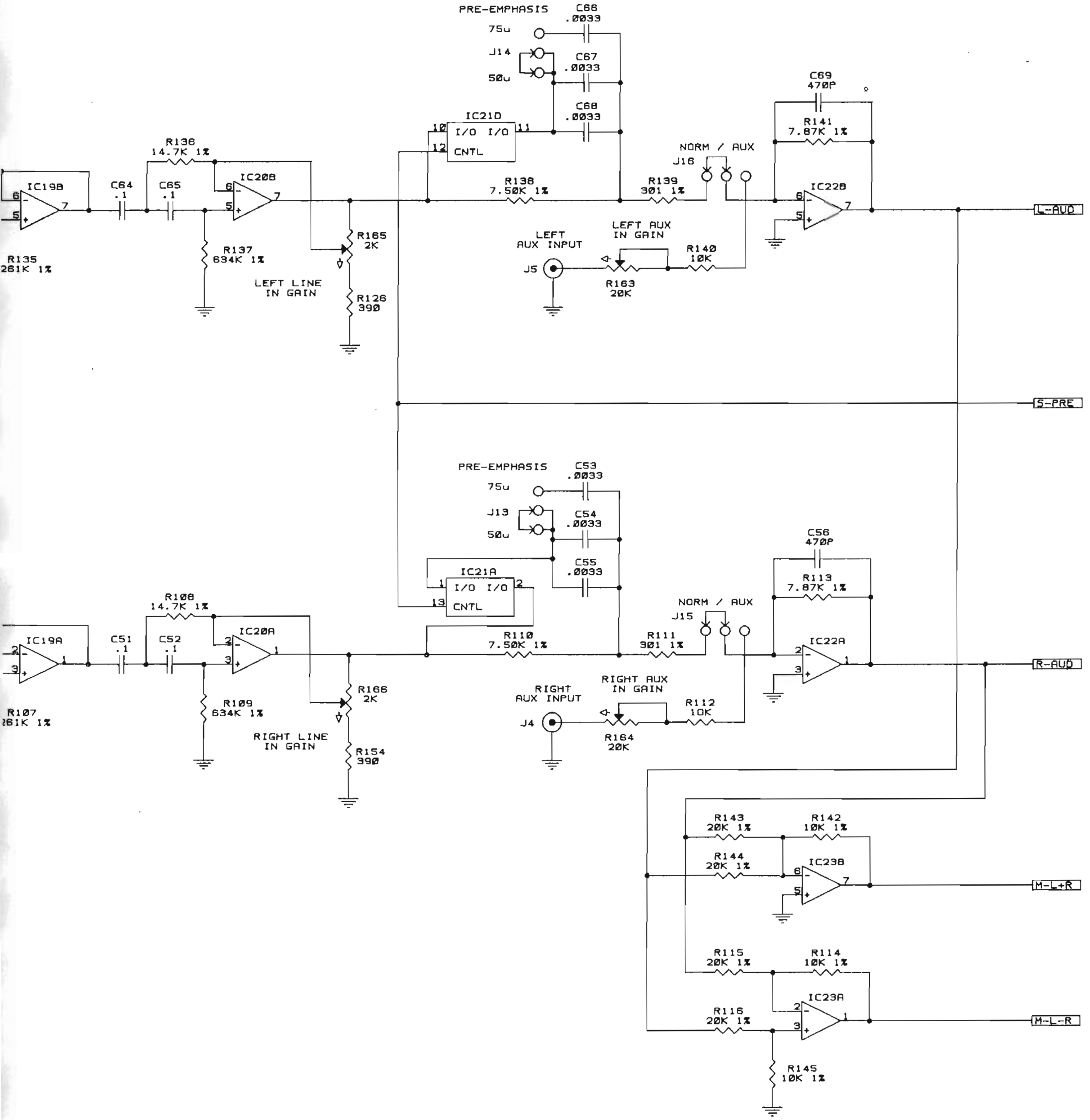
Mouser Electronics - Call: 1-800-34-MOUSER

Digi-Key Corporation - Call: 1-800-DIGI-KEY

ACTIVE (div. of Future Electronics) - Call: 1-800-ACTIVE-6



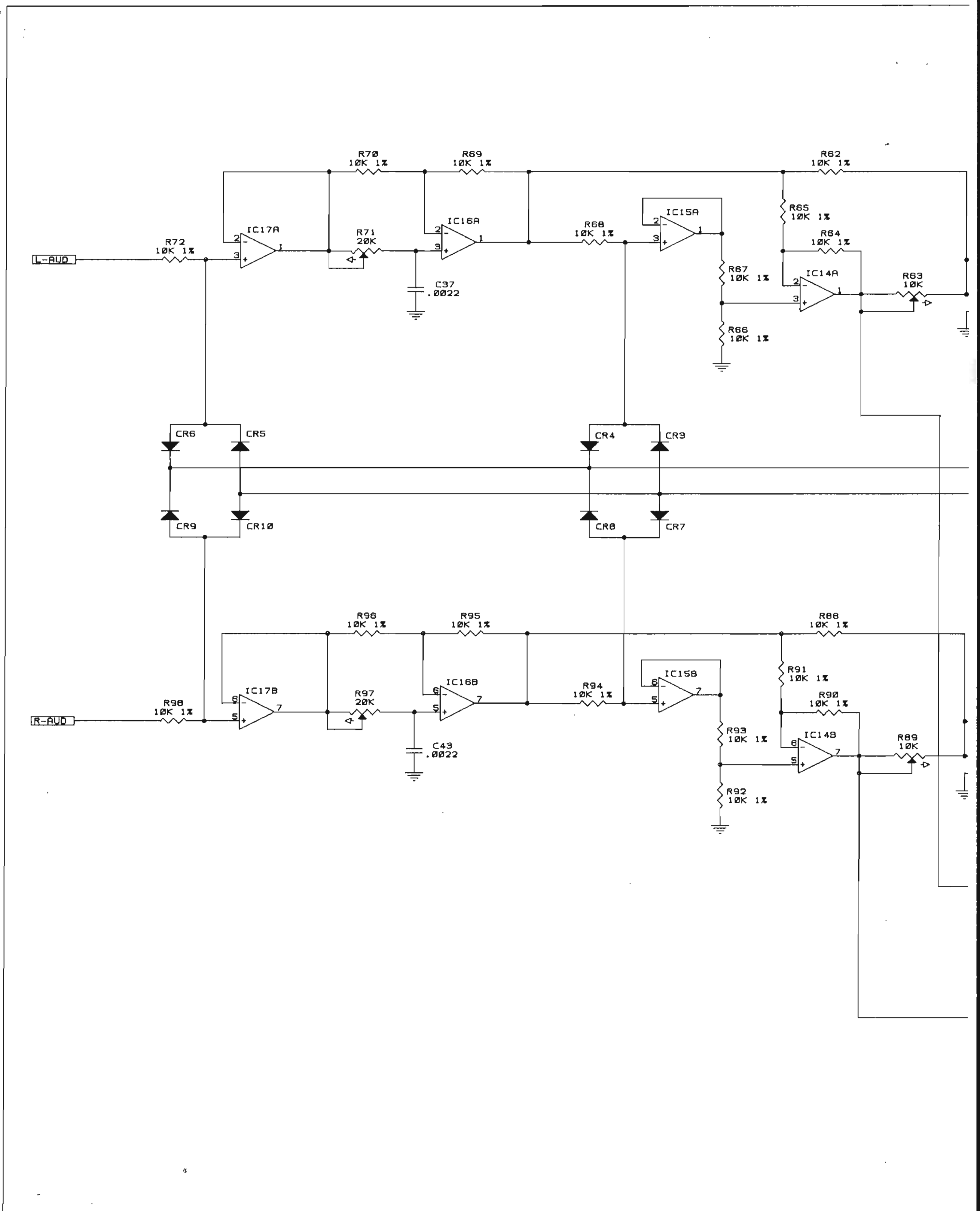
C59
100P
R131
9.09K 1%
J12
R127
22.6K 1%
R129
6.04K 1%
IC18B
R128
22.6K 1%
R130
6.04K 1%
J11
R132
9.09K 1%
C60
100P
C61
.1
C62
.1
C63
.1
R134
22.6K 1%
IC19B
R133
39.2K 1%
R135
261K 1%
C64
.1
C65
.1
R136
14.7K 1%
J6
LEFT
LINE INPUT
GND
RIGHT
LINE INPUT
GND
C44
100P
R103
9.09K 1%
J10
R99
22.6K 1%
R101
6.04K 1%
IC18A
R100
22.6K 1%
R102
6.04K 1%
J9
R104
9.09K 1%
C45
100P
C46
.1
C47
.1
C48
.1
R106
22.6K 1%
IC19A
R105
39.2K 1%
R107
261K 1%
C51
.1
C52
.1
R108
14.7K 1%



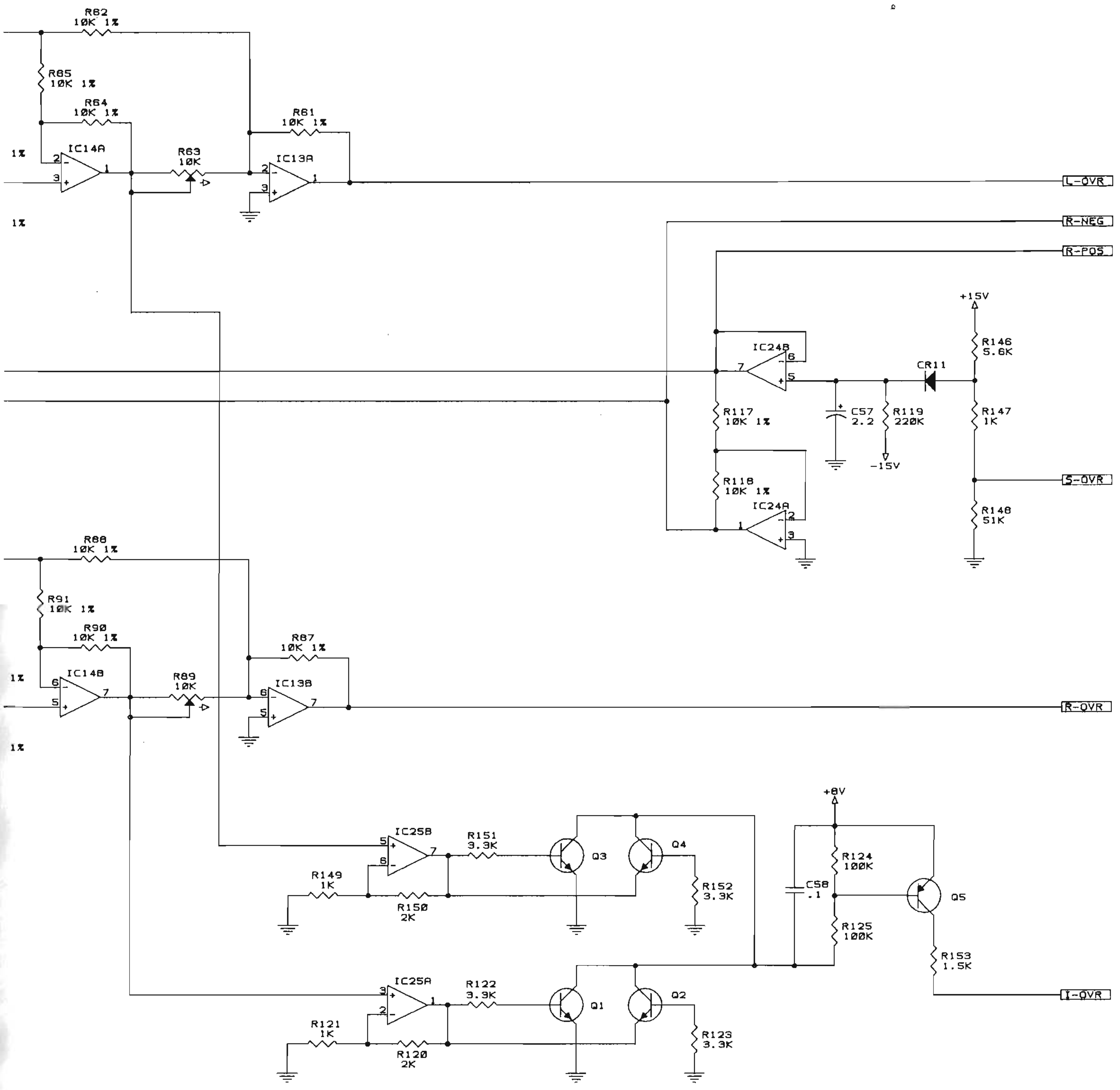
706 – STEREO GENERATOR

INOVONICS, INC.
1305 FAIR AVENUE – SANTA CRUZ, CA 95060
PHONE: (408) 458-0552 FAX: (408) 458-0554

Title		
INPUT SCHEMATIC		
Size: C	Document Number: 188000	REV: B
Date: June 7, 1991	Sheet 2 of 5	



L-AUD
R-AUD
R72 10K 1%
IC17A
R70 10K 1%
R71 20K
C37 .0022
R69 10K 1%
IC16A
R68 10K 1%
IC15A
R67 10K 1%
R66 10K 1%
R62 10K 1%
R65 10K 1%
R64 10K 1%
IC14A
R63 10K
CR6
CR5
CR4
CR3
CR9
CR10
CR8
CR7
R98 10K 1%
IC17B
R96 10K 1%
R97 20K
C43 .0022
R95 10K 1%
IC16B
R94 10K 1%
IC15B
R93 10K 1%
R92 10K 1%
R88 10K 1%
R91 10K 1%
R90 10K 1%
IC14B
R89 10K



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I N O V O N I C S, I N C.
1305 FAIR AVENUE - SANTA CRUZ, CA 95060
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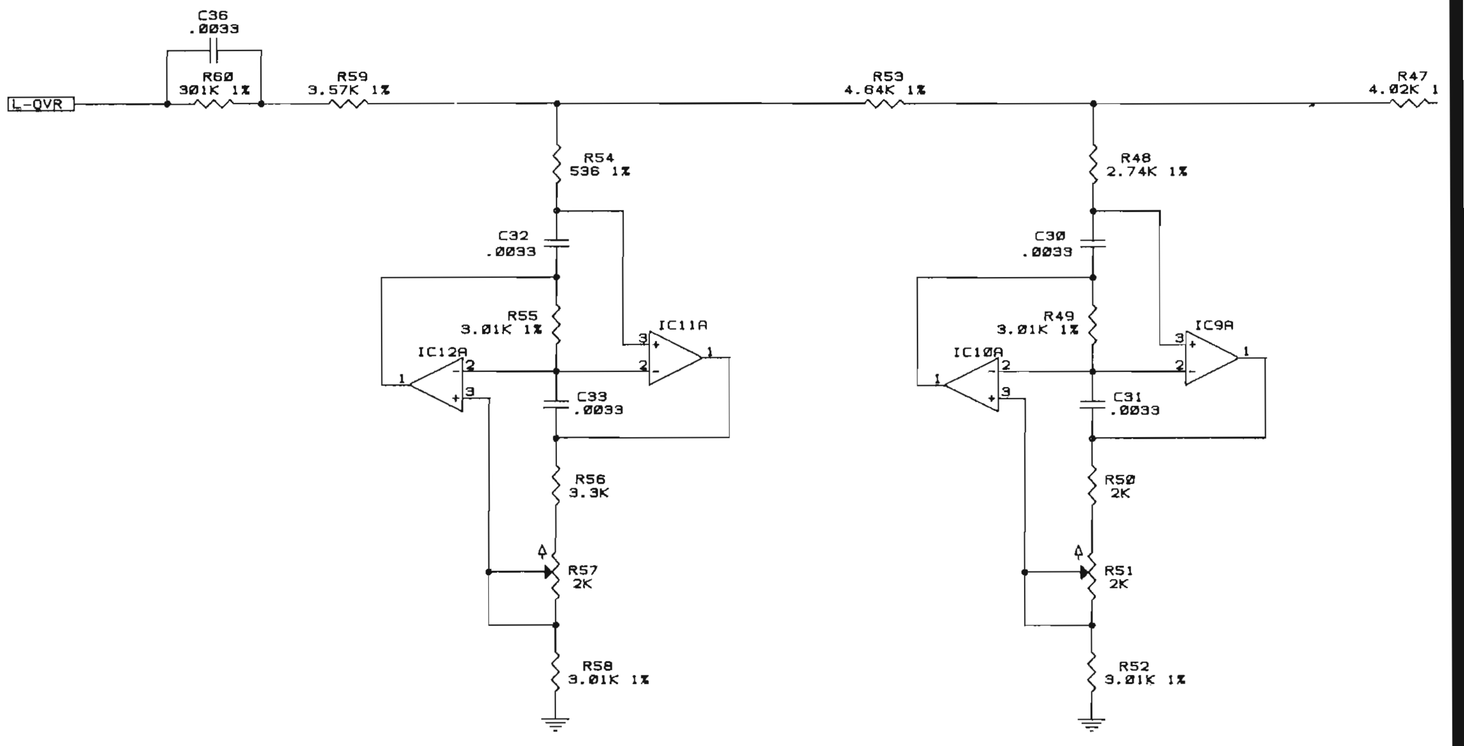
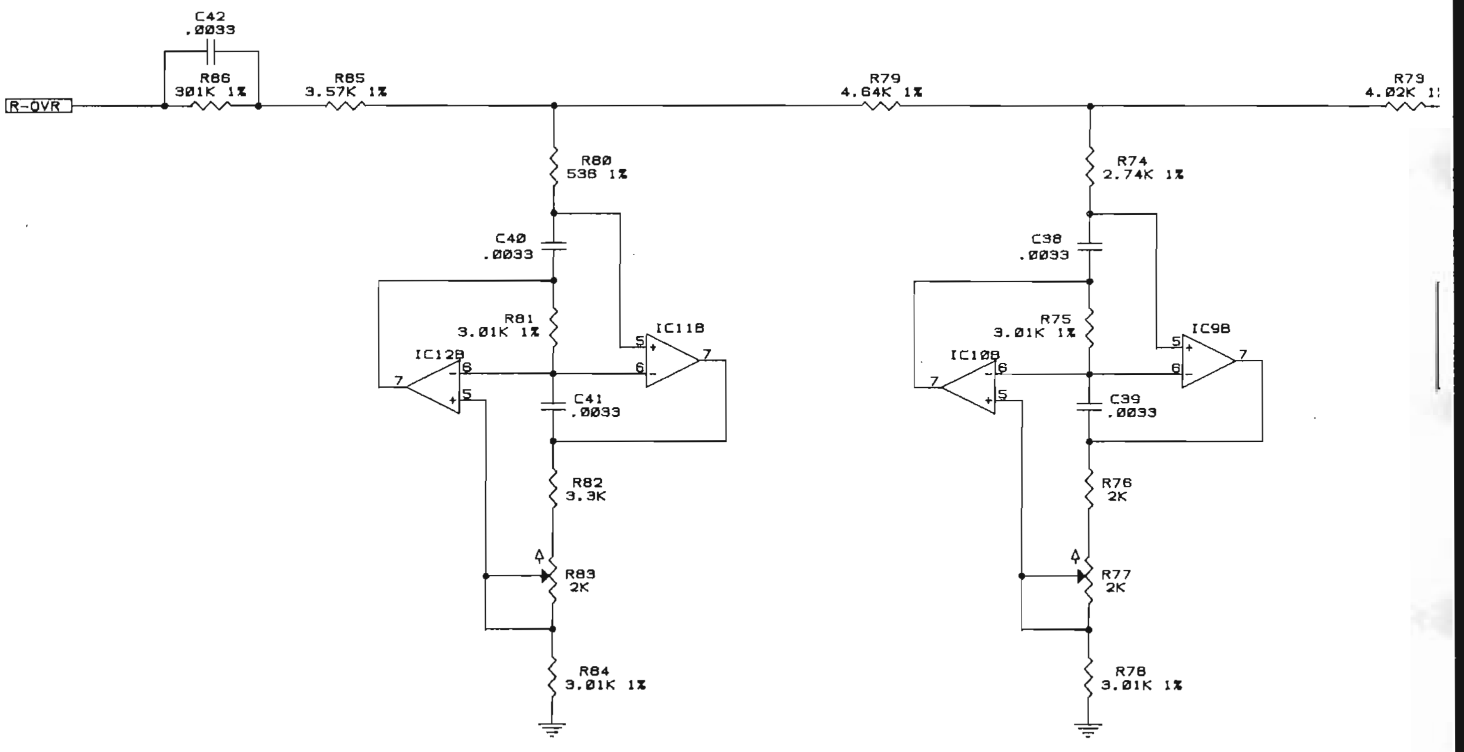
Title		
OVERSHOOT SCHEMATIC		
Size	Document Number	REV
C	188000	B
Date: June 7, 1991	Sheet 3 of 5	



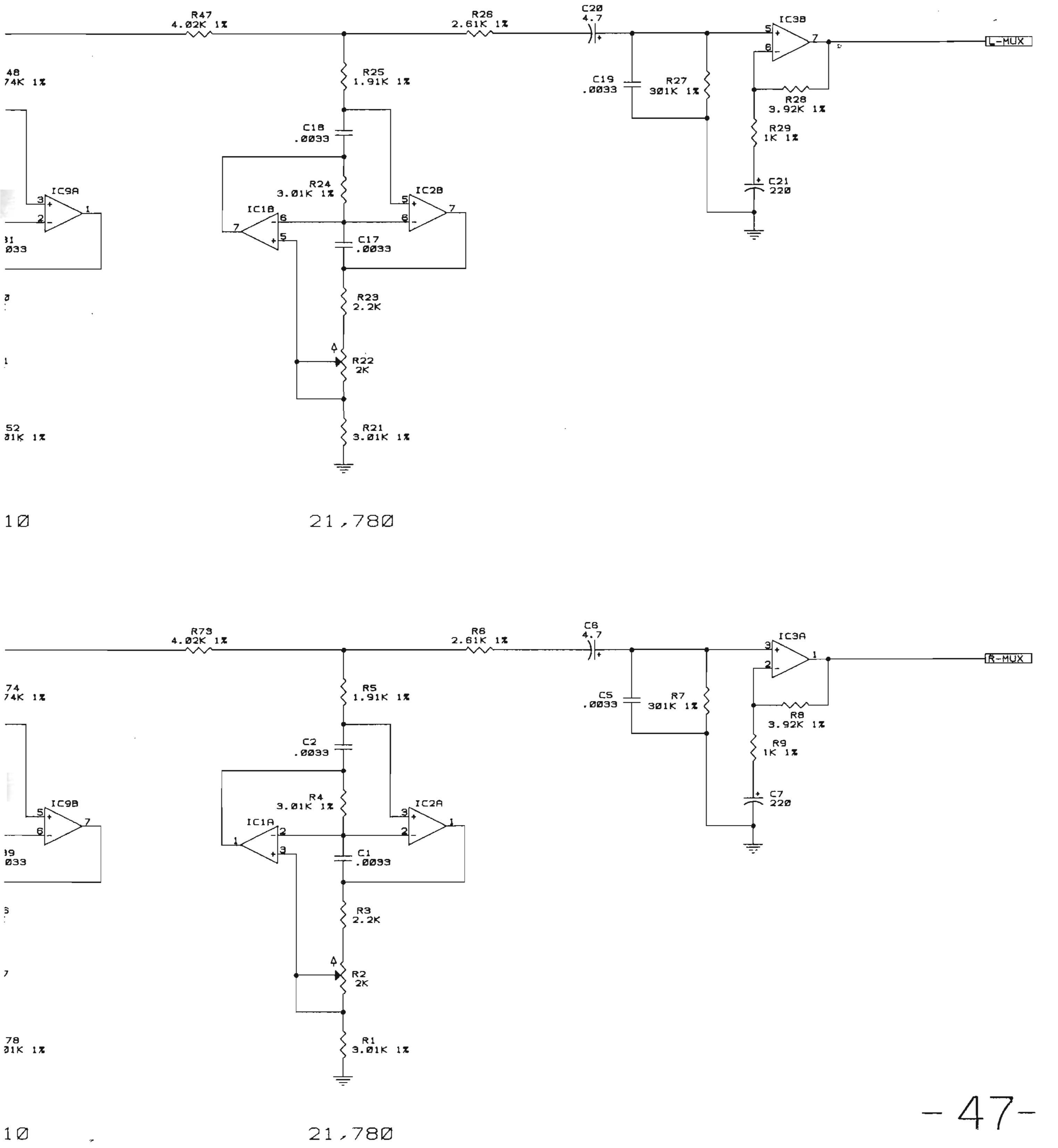
34,570

19,110



34,570

19,110



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I N O V O N I C S, I N C.
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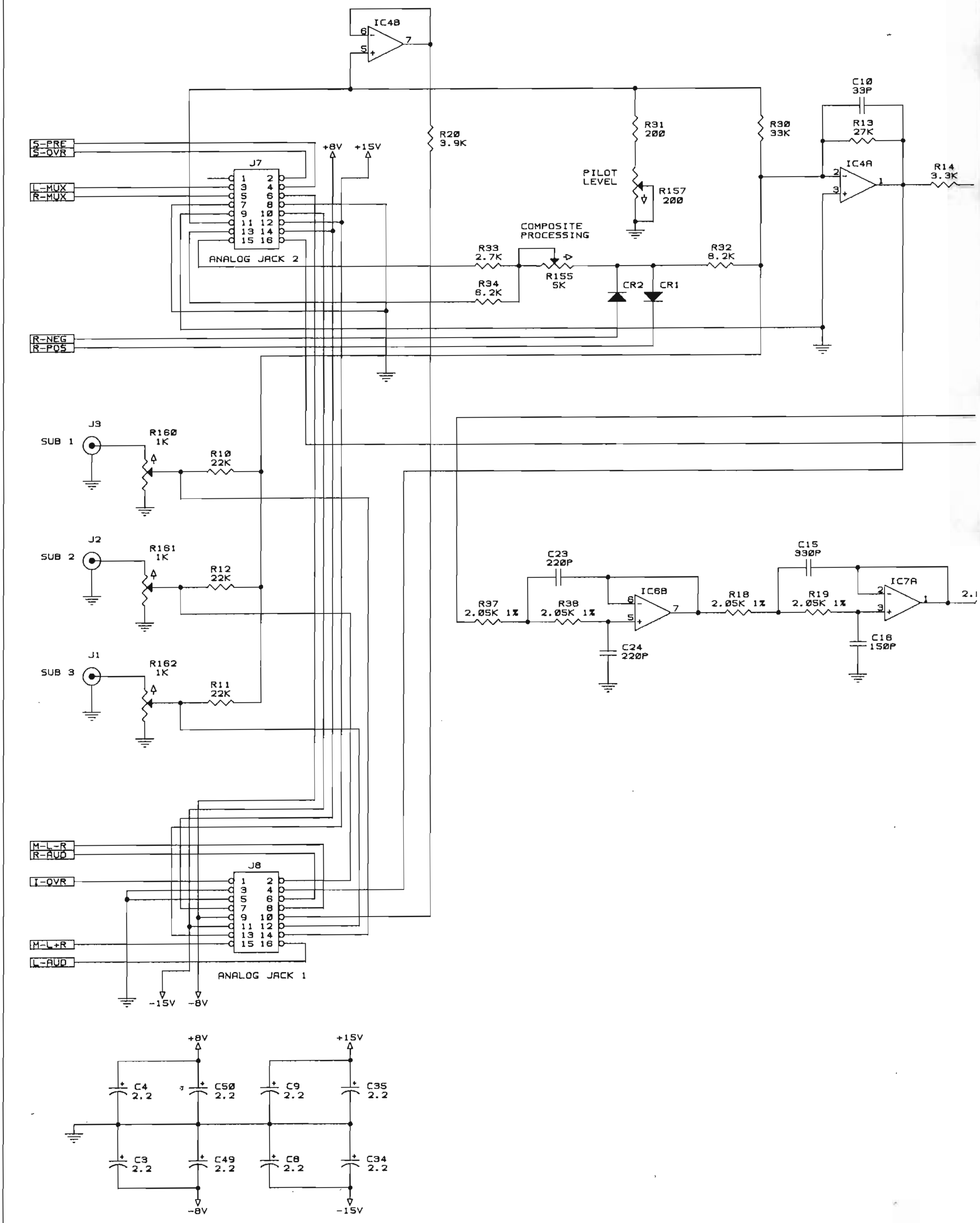
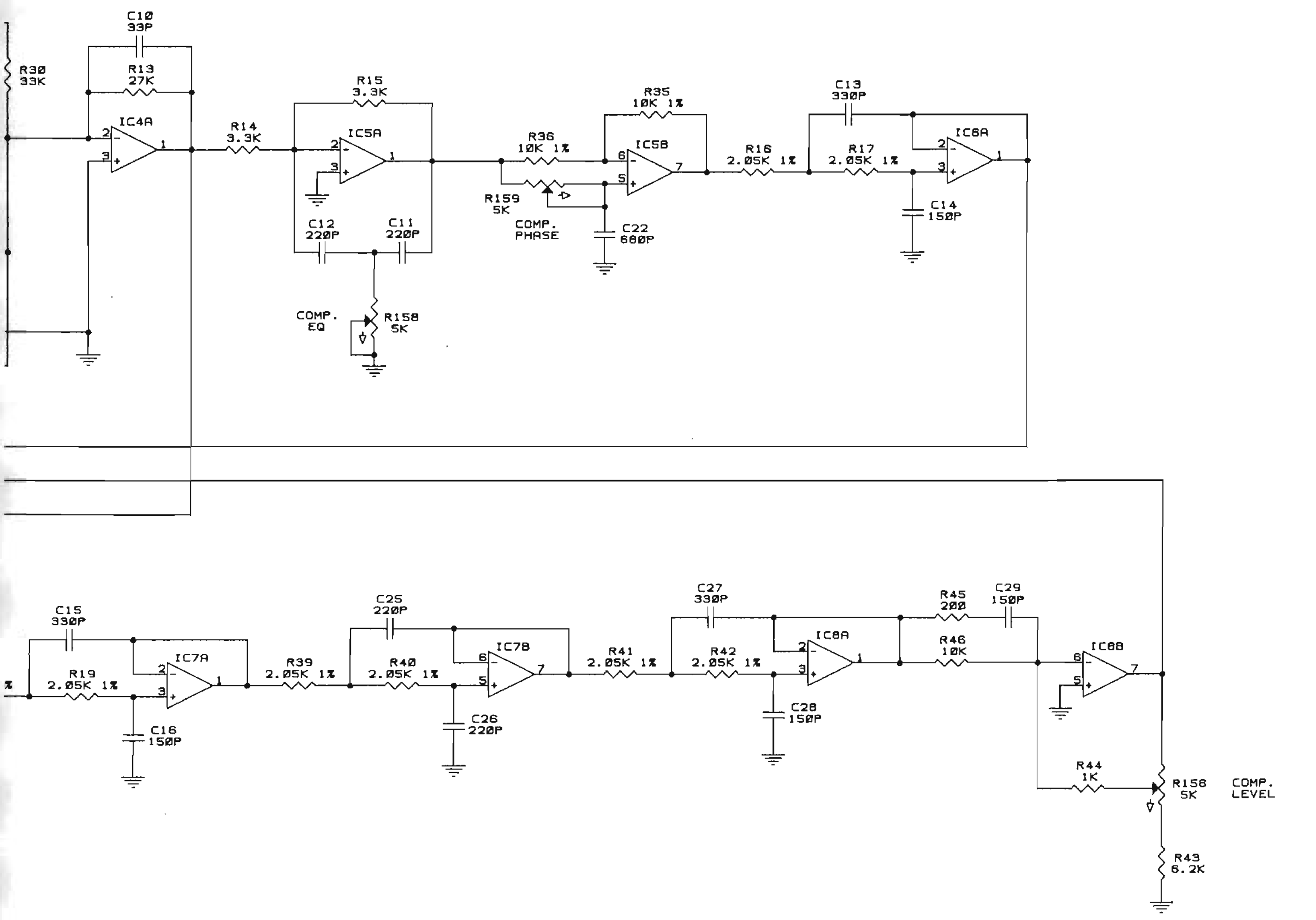
Title		
F I L T E R S C H E M A T I C		
Size	Document Number	REV
C	1 8 8 0 0 0	B
Date: June 7, 1991	Sheet 4 of 5	



IC4B
R20
3.9K
R31
200
R30
33K
C10
33P
R13
27K
IC4A
R14
3.3K
S-PRE
S-OVR
+8V
+15V
J7
L-MUX
R-MUX
PILOT LEVEL
R157
200
COMPOSITE PROCESSING
ANALOG JACK 2
R33
2.7K
R155
5K
R32
8.2K
R34
8.2K
CR2
CR1
R-NEG
R-POS
J3
SUB 1
R160
1K
R10
22K
J2
SUB 2
R161
1K
R12
22K
C23
220P
C15
330P
IC6B
IC7A
R37
2.05K 1%
R38
2.05K 1%
R18
2.05K 1%
R19
2.05K 1%
C24
220P
C16
150P
J1
SUB 3
R162
1K
R11
22K
M-L-R
R-AUD
I-OVR
J8
M-L+R
L-AUD
ANALOG JACK 1
-15V
-8V
+8V
+15V
C4
2.2
C50
2.2
C9
2.2
C35
2.2
C3
2.2
C49
2.2
C8
2.2
C34
2.2
-8V
-15V



706 - STEREO GENERATOR

INOVONICS, INC.
1305 FAIR AVENUE - SANTA CRUZ, CA 95060
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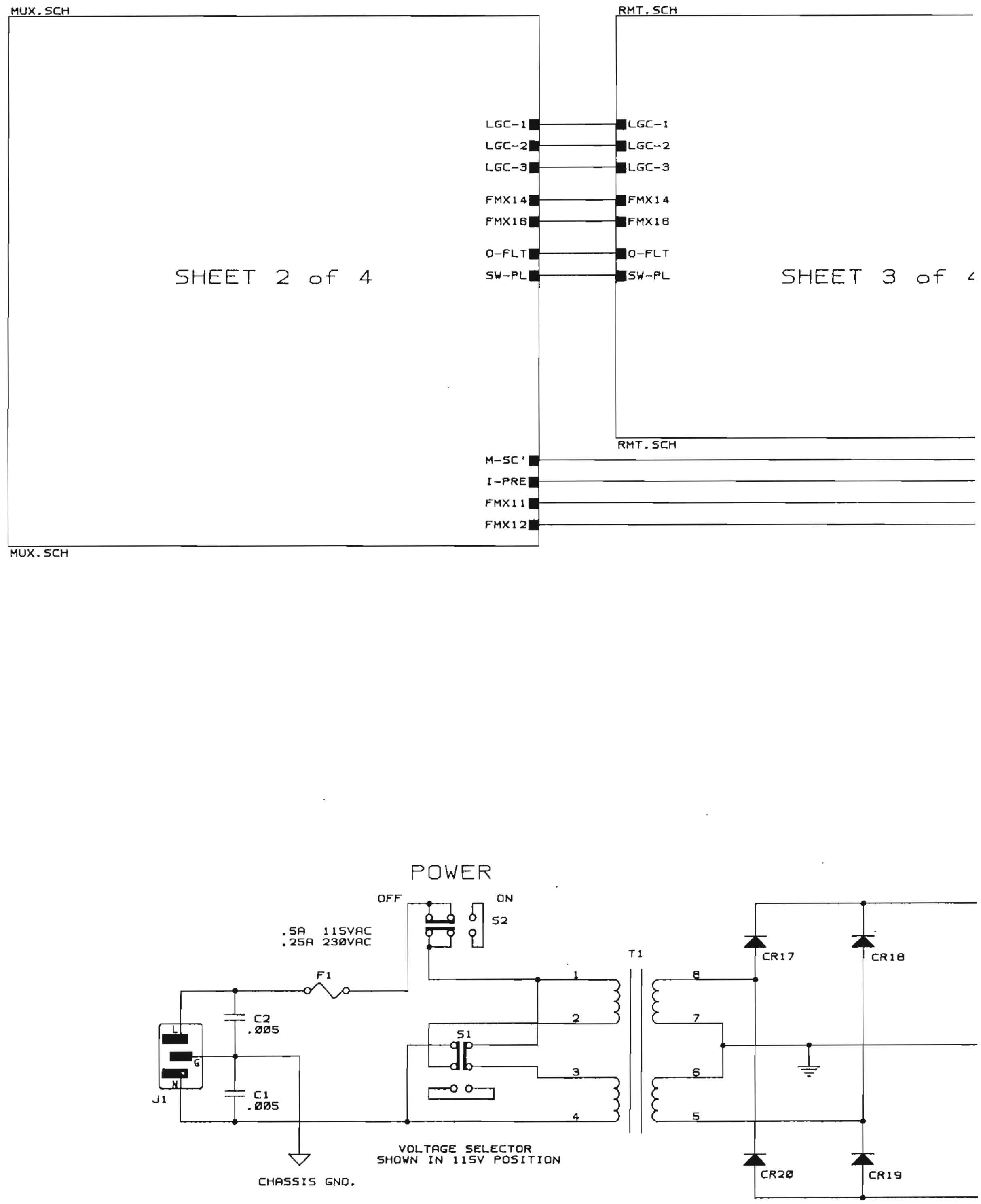
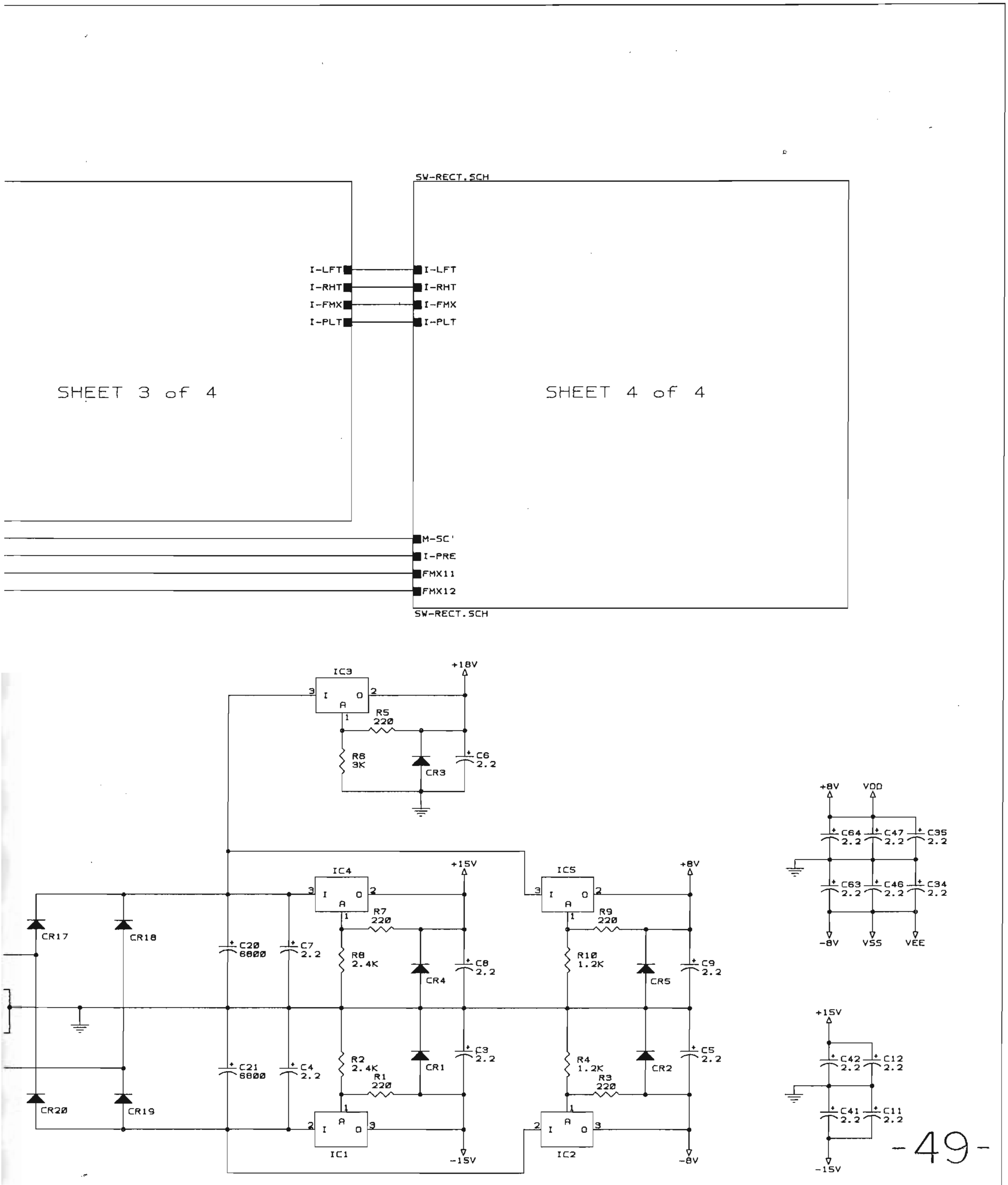
Title		
OUTPUT SCHEMATIC		
Size	Document Number	REV
C	188000	B
Date: June 7, 1991	Sheet 5 of 5	



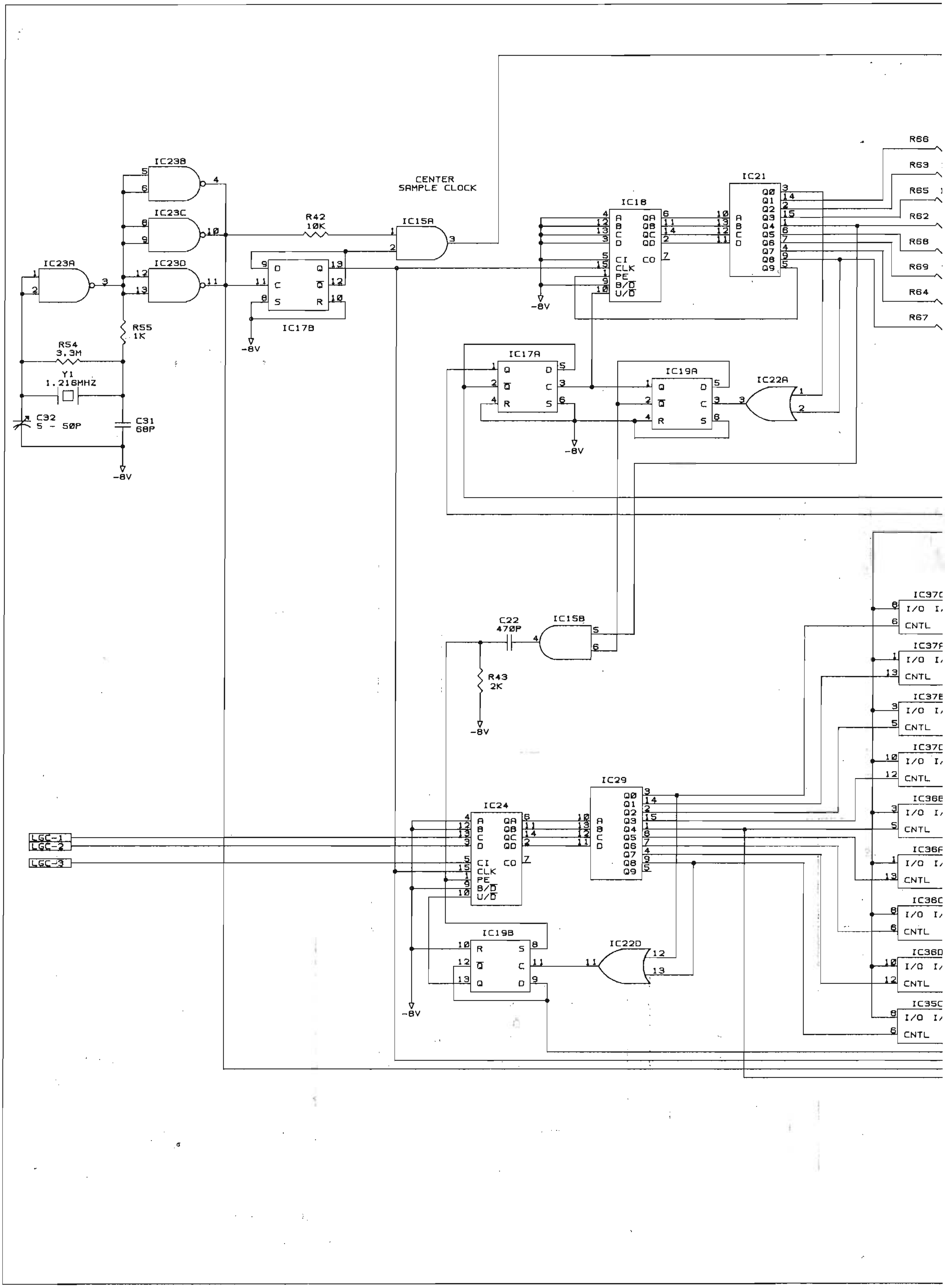
MUX.SCH
SHEET 2 of 4
LGC-1
LGC-2
LGC-3
FMX14
FMX16
O-FLT
SW-PL
M-SC'
I-PRE
FMX11
FMX12
RMT.SCH
SHEET 3 of
POWER
OFF
ON
S2
.5A 115VAC
.25A 230VAC
F1
C2
.005
C1
.005
J1
S1
T1
CR17
CR18
CR20
CR19
VOLTAGE SELECTOR
SHOWN IN 115V POSITION
CHASSIS GND.

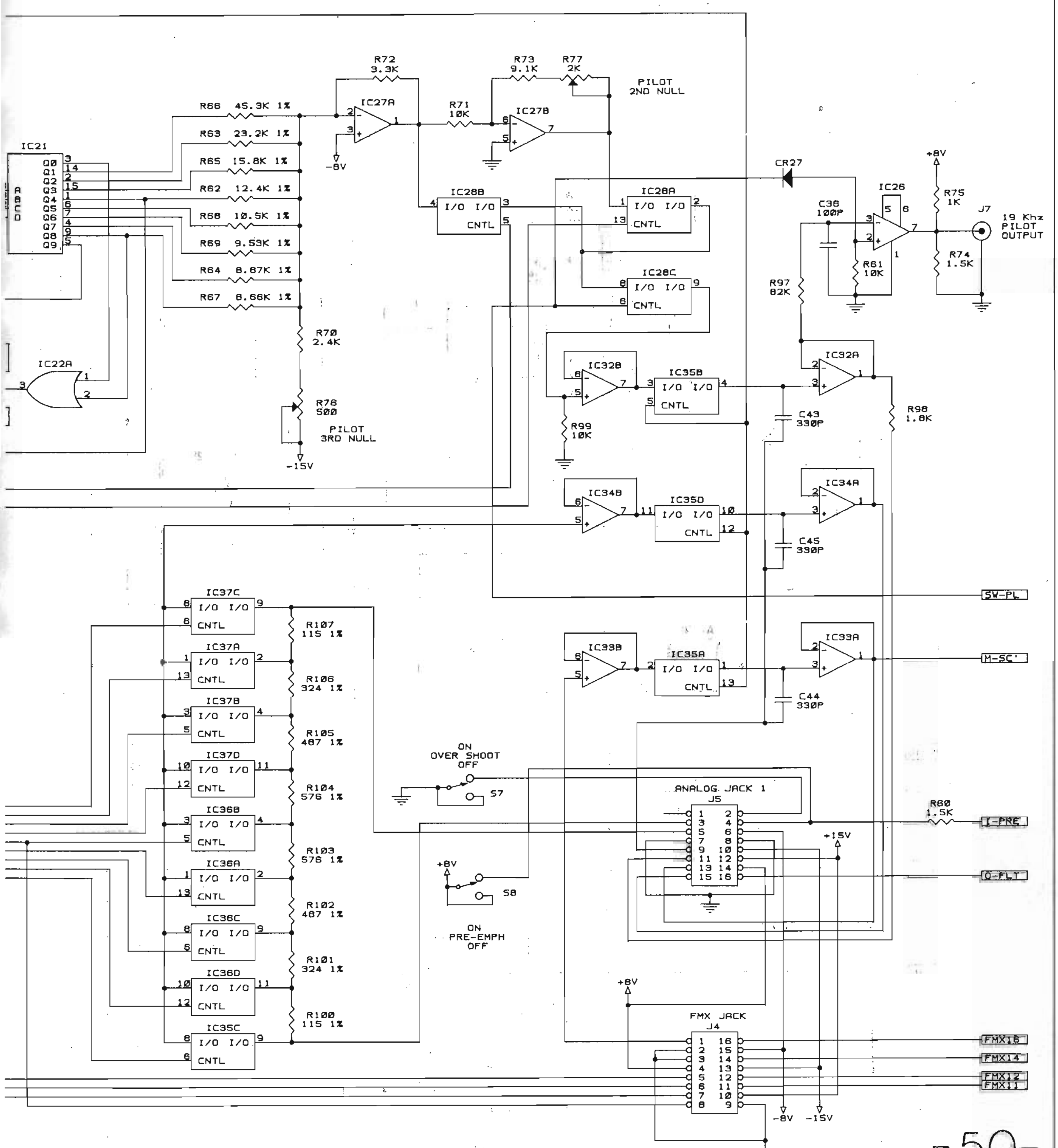


706 - STEREO GENERATOR

INOVONICS, INC.
1305 Fair Avenue - Santa Cruz, CA 95060
PHONE: (408) 458-0552 FAX: (408) 458-0554

Title		
706 - DIGITAL BOARD		
Size	Document Number	REV
C	187700	B
Date: June 7, 1991	Sheet 1 of 4	


CENTER SAMPLE CLOCK
IC23A
IC23B
IC23C
IC23D
IC15A
IC15B
IC17A
IC17B
IC18
IC19A
IC19B
IC21
IC22A
IC22D
IC24
IC29
R42 10K
R43 2K
R54 3.3M
R55 1K
Y1 1.216MHZ
C22 470P
C31 68P
C32 5 - 50P
-8V
R66
R63
R65
R62
R68
R69
R64
R67
LGC-1
LGC-2
LGC-3
CNTL



-50-

NOTE: IF THE FMX OPTION IS NOT INSTALLED, MAKE SURE THAT THE 'FMX DUMMY PLUG' IS INSTALLED IN J4.

706 - STEREO GENERATOR

INOVONICS, INC.
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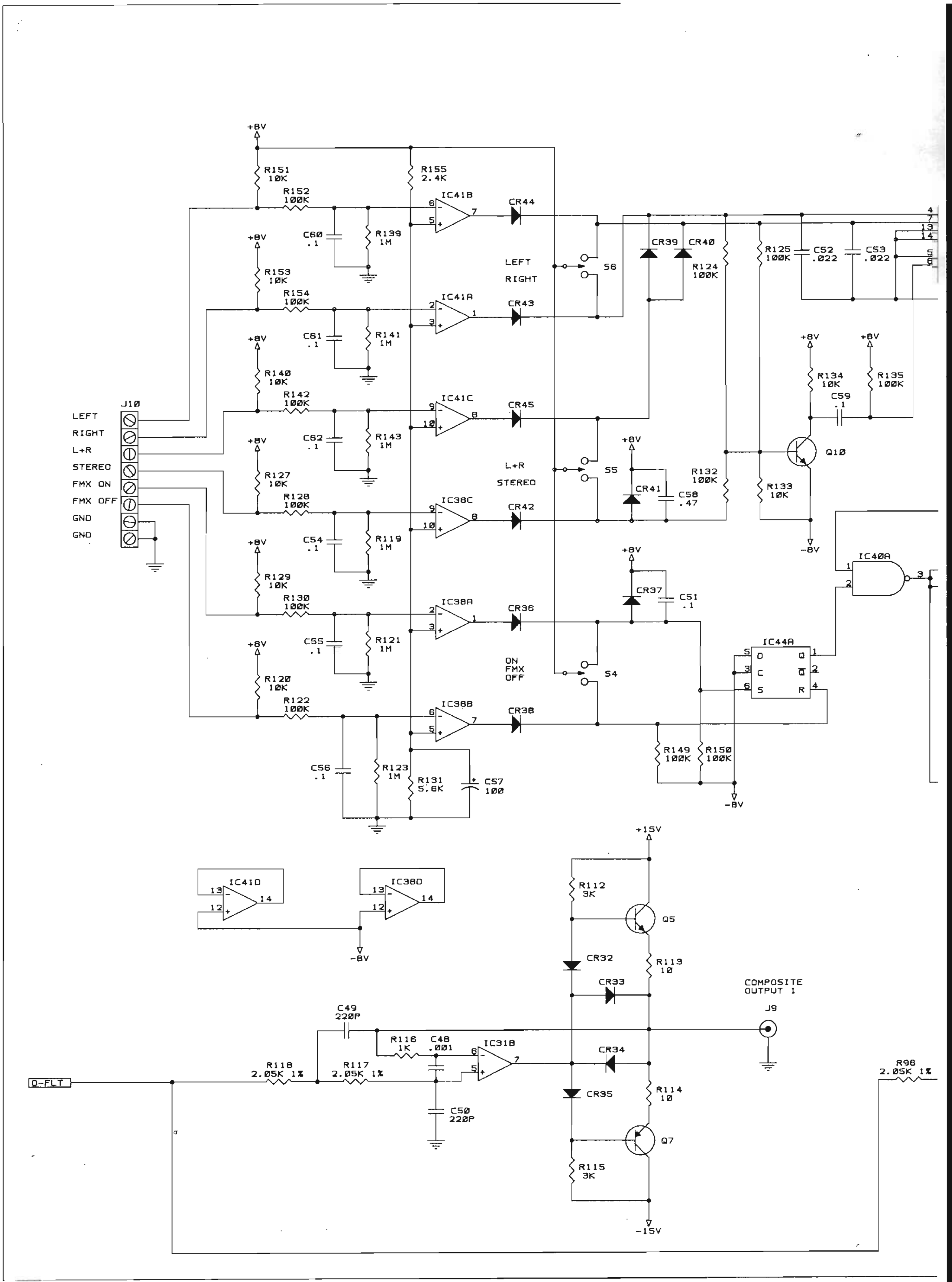
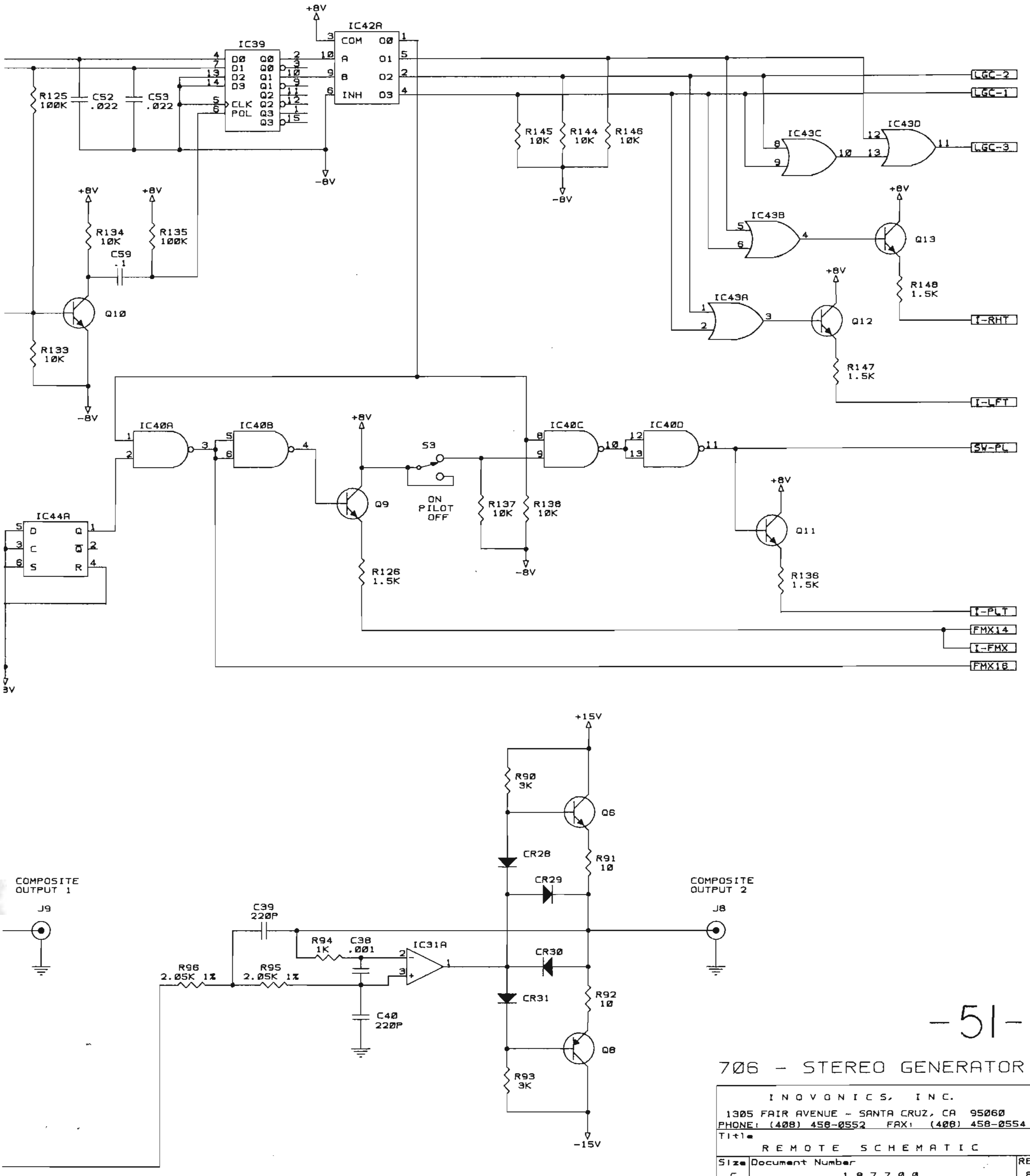
Title	MUX SCHEMATIC	
Size C	Document Number 187700	REV B
Date: June 7, 1991	Sheet 2 of 4	



+8V
R151
10K
R155
2.4K
R152
100K
IC41B
CR44
C60
.1
R139
1M
LEFT
RIGHT
S6
CR39
CR40
R124
100K
R125
100K
C52
.022
C53
.022
R153
10K
R154
100K
IC41A
CR43
C61
.1
R141
1M
R140
10K
R142
100K
IC41C
CR45
C62
.1
R143
1M
R134
10K
R135
100K
C59
.1
Q10
J10
LEFT
RIGHT
L+R
STEREO
FMX ON
FMX OFF
GND
GND
R127
10K
R128
100K
IC38C
CR42
C54
.1
R119
1M
L+R
STEREO
S5
CR41
C58
.47
R132
100K
R133
10K
-8V
R129
10K
R130
100K
IC38A
CR36
C55
.1
R121
1M
CR37
C51
.1
IC40A
IC44A
ON
FMX
OFF
S4
R120
10K
R122
100K
IC38B
CR38
C56
.1
R123
1M
R131
5.6K
C57
100
R149
100K
R150
100K
-8V
+15V
IC41D
IC38D
R112
3K
Q5
CR32
R113
10
CR33
COMPOSITE
OUTPUT 1
J9
C49
220P
R116
1K
C48
.001
IC31B
CR34
D-FLT
R118
2.05K 1%
R117
2.05K 1%
C50
220P
CR35
R114
10
Q7
R115
3K
-15V
R96
2.05K 1%

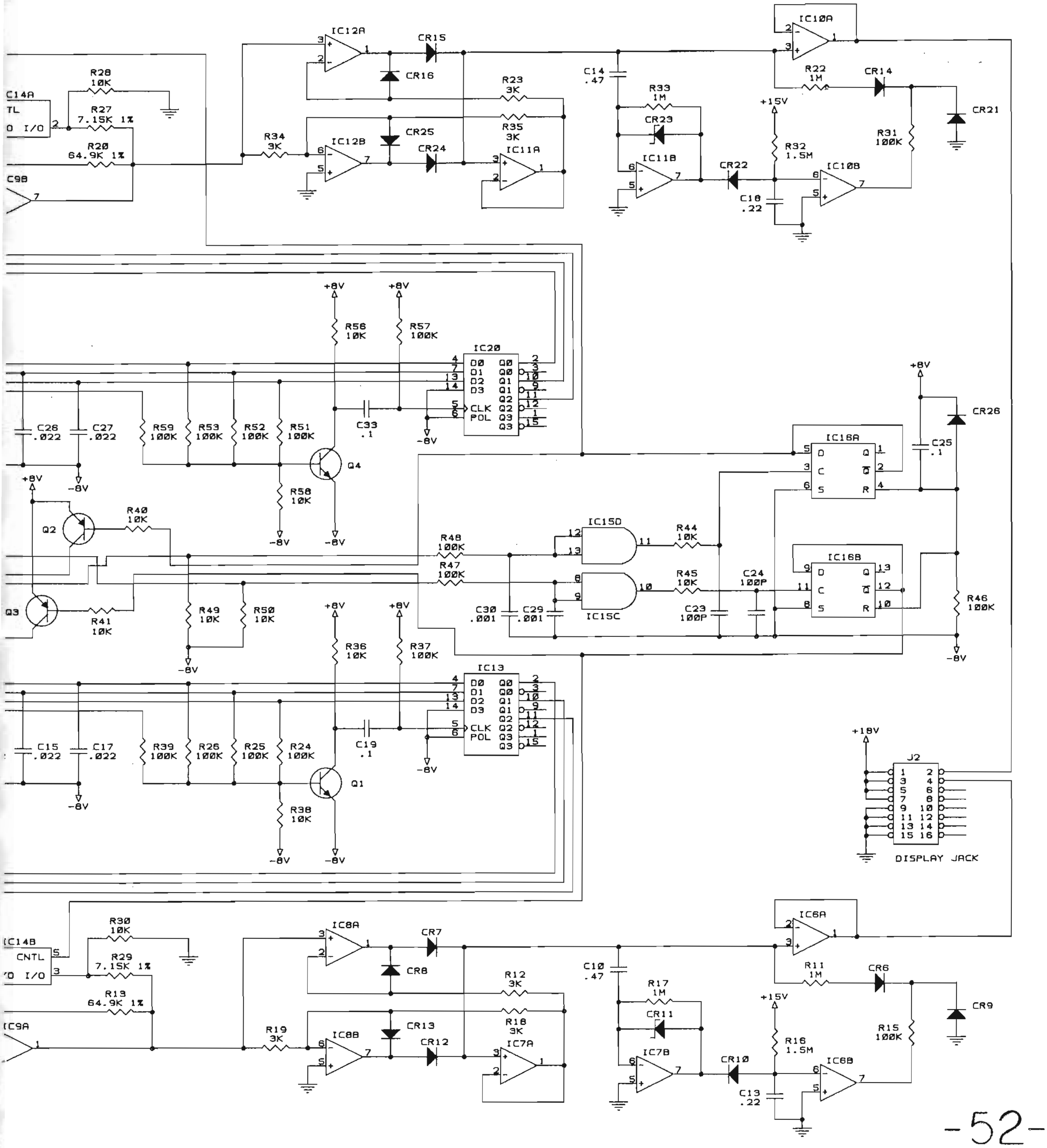


-51-

706 - STEREO GENERATOR

INOVONICS, INC.
1305 FAIR AVENUE - SANTA CRUZ, CA 95060
PHONE: (408) 458-0552 FAX: (408) 458-0554

Title		
REMOTE SCHEMATIC		
Size: C	Document Number: 187700	REV: B
Date: June 7, 1991	Sheet 3 of 4	



706 - STEREO GENERATOR

INOVONICS, INC.
1305 FAIR AVENUE - SANTA CRUS, CA 95060
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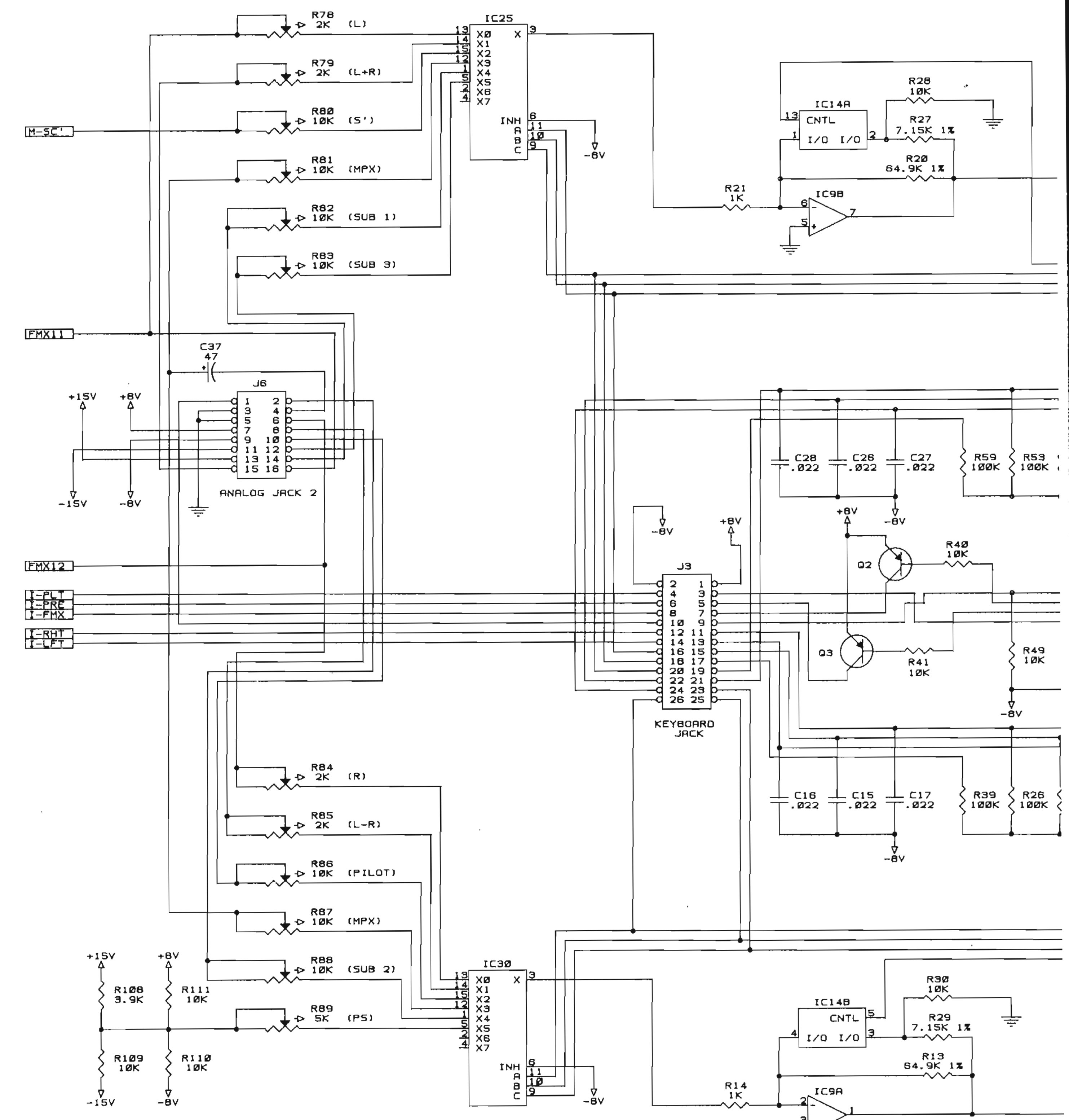
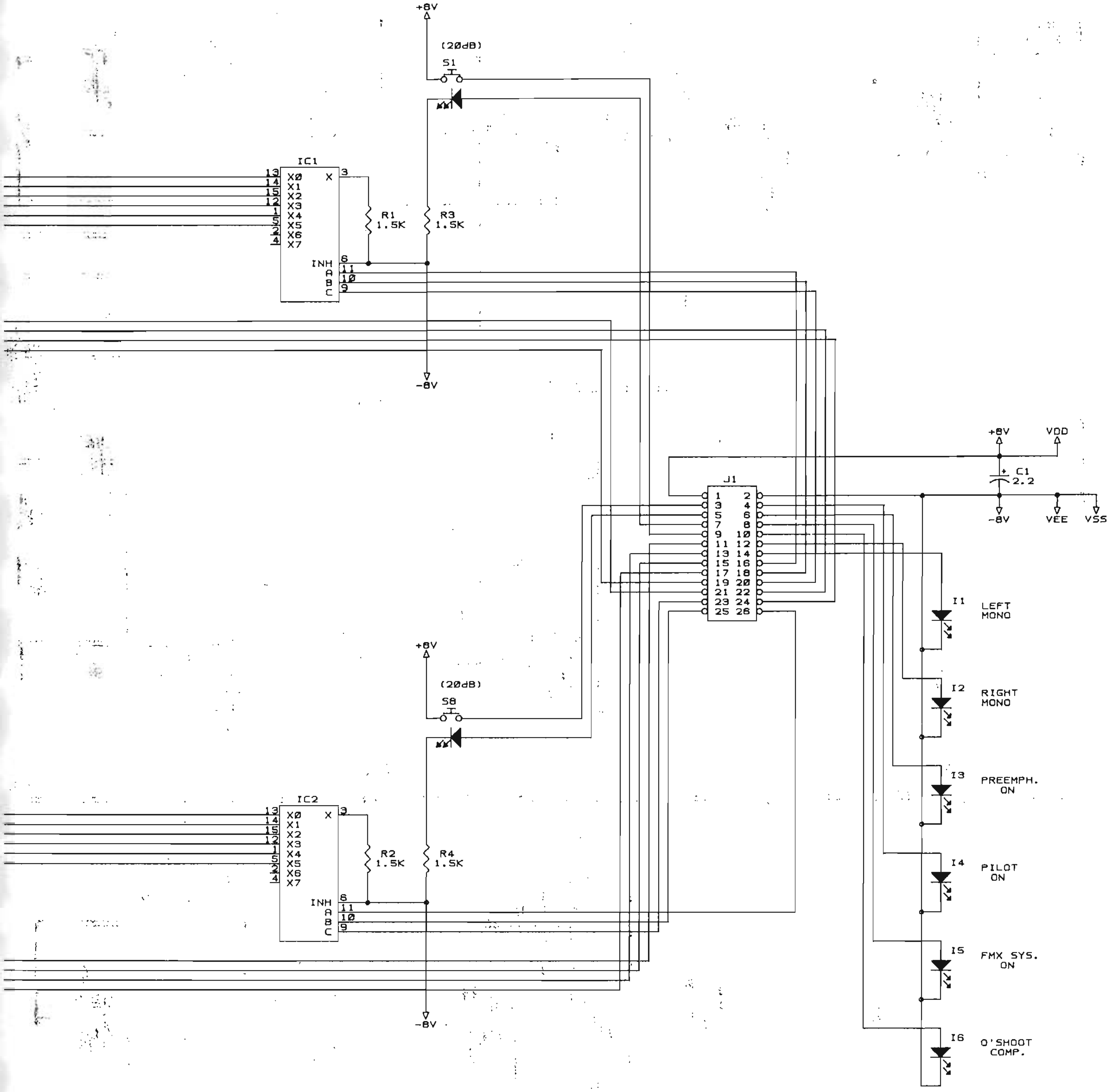
Title		
SW-RECT. SCHEMATIC		
Size: C	Document Number: 187700	REV: B
Date: June 7, 1991	Sheet 4 of 4	



R78 2K (L)
R79 2K (L+R)
R80 10K (S')
R81 10K (MPX)
R82 10K (SUB 1)
R83 10K (SUB 3)
IC25
X0 X1 X2 X3 X4 X5 X6 X7 X
INH A B C
-8V
M-SC'
FMX11
FMX12
C37 47
J6
ANALOG JACK 2
+15V +8V -15V -8V
IC14A CNTL I/O I/O
R28 10K
R27 7.15K 1%
R20 64.9K 1%
R21 1K
IC9B
C28 .022 C26 .022 C27 .022
R59 100K R53 100K
J3
KEYBOARD JACK
Q2 Q3
R40 10K
R41 10K
R49 10K
I-PLT
I-PRE
I-FMX
I-RHT
I-LFT
C16 .022 C15 .022 C17 .022
R39 100K R26 100K
R84 2K (R)
R85 2K (L-R)
R86 10K (PILOT)
R87 10K (MPX)
R88 10K (SUB 2)
R89 5K (PS)
R108 3.9K
R111 10K
R109 10K
R110 10K
IC30
IC14B CNTL I/O I/O
R30 10K
R29 7.15K 1%
R13 64.9K 1%
R14 1K
IC9A



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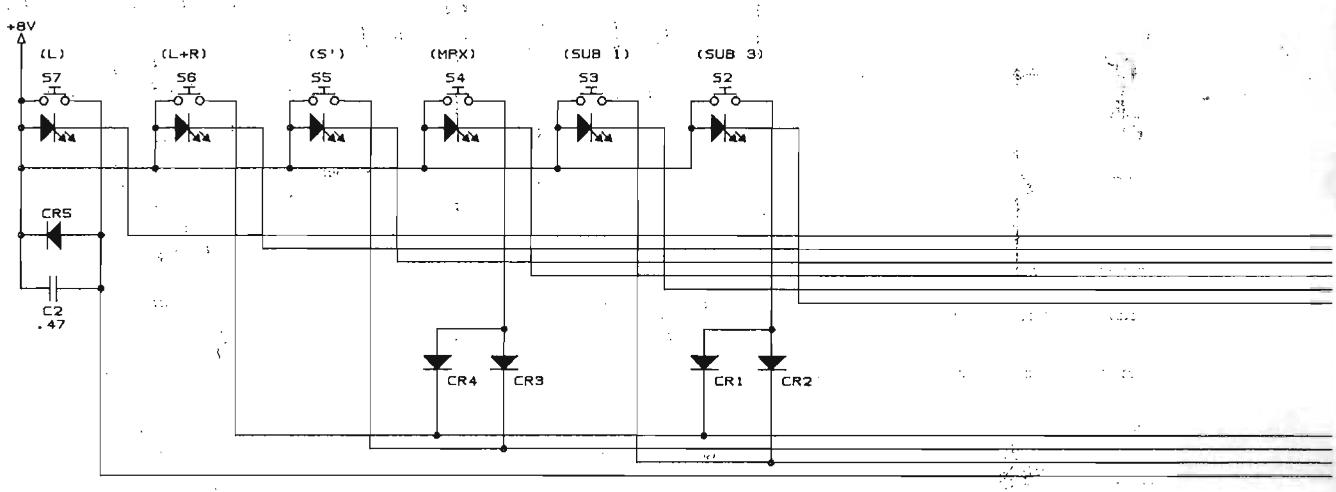
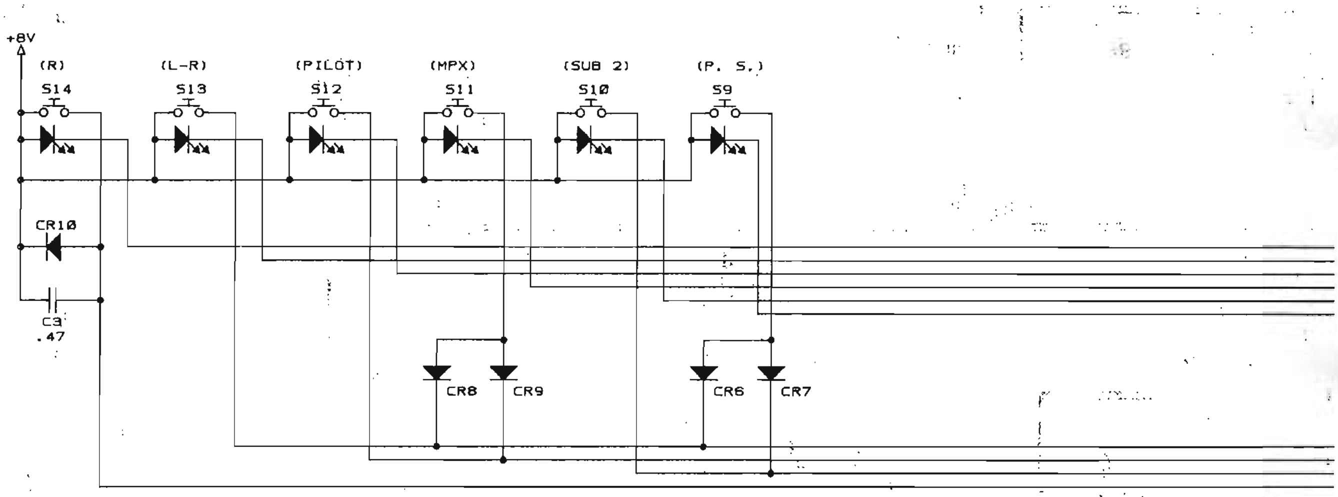
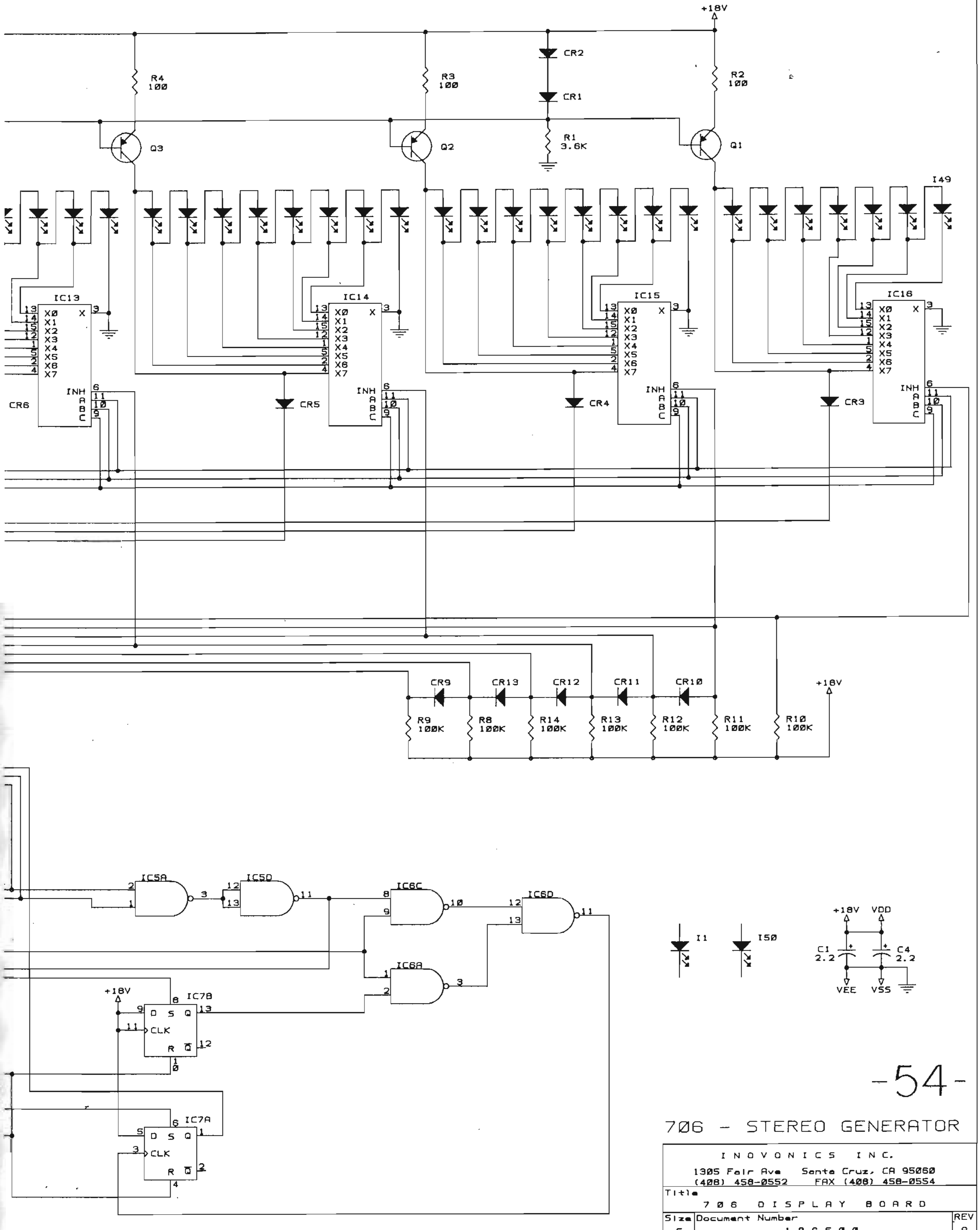
INOVONICS, INC.
1305 FAIR AVENUE - SANTA CRUZ, CA 95060
PHONE: (408) 458-0552 FAX: (408) 458-0554

Title: KEY ENCODER SCHEMATIC		
Size: C	Document Number: 186800	REV: A
Date: June 7, 1991	Sheet 1 of 1	

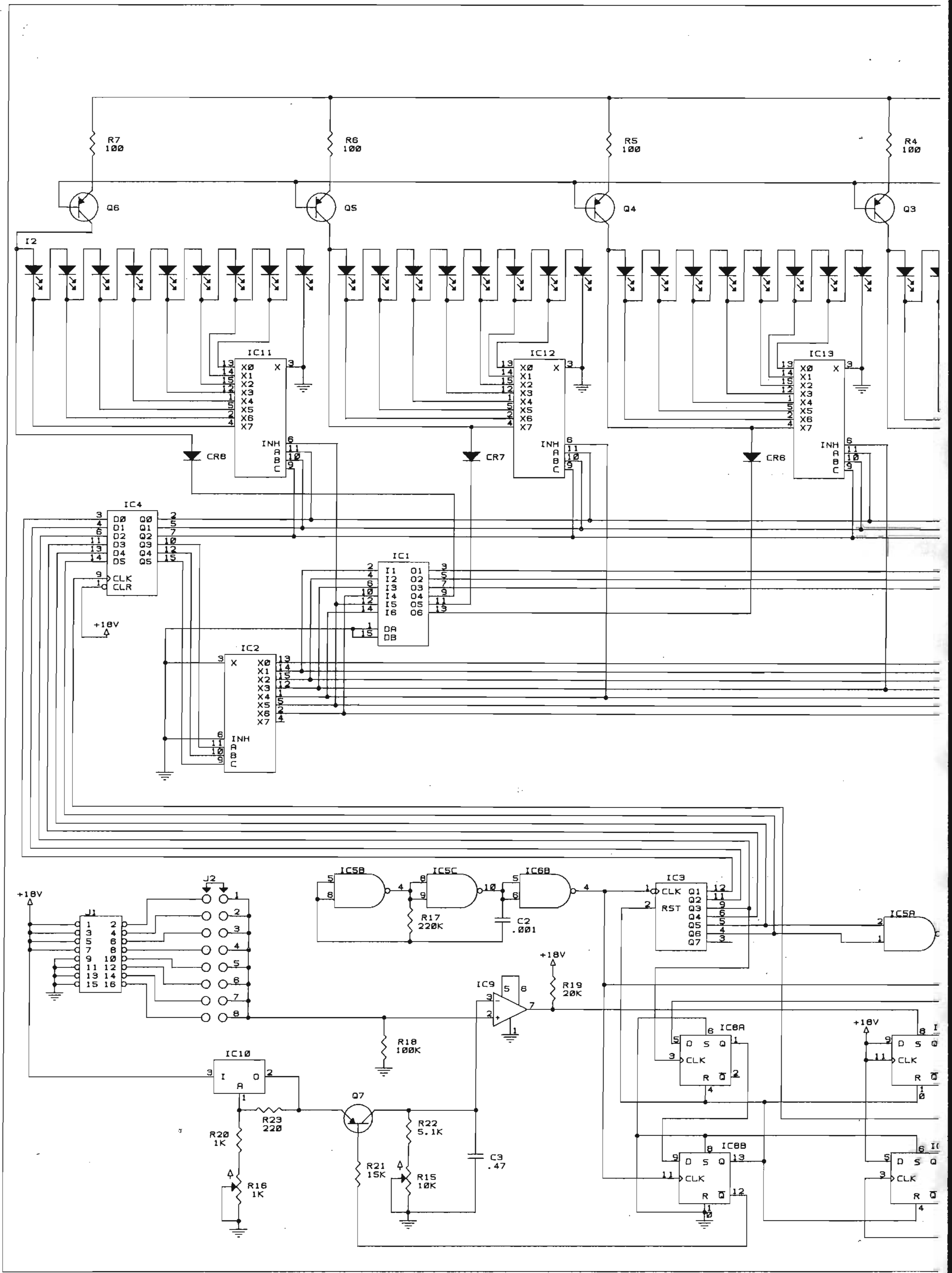

+8V
(L)
(L+R)
(S')
(MPX)
(SUB 1)
(SUB 3)
S7
S6
S5
S4
S3
S2
CR5
C2
.47
CR4
CR3
CR1
CR2


+8V
(R)
(L-R)
(PILOT)
(MPX)
(SUB 2)
(P. S.)
S14
S13
S12
S11
S10
S9
CR10
C3
.47
CR8
CR9
CR6
CR7



706 - STEREO GENERATOR

INOVONICS INC. 1305 Fair Ave Santa Cruz, CA 95060 (408) 458-0552 FAX (408) 458-0554		
Title 706 DISPLAY BOARD		
Size C	Document Number 186500	REV A
Date: June 7, 1991	Sheet 1 of 1	



R7 100
R6 100
R5 100
R4 100
Q6
Q5
Q4
Q3
I2
IC11
IC12
IC13
CR8
CR7
CR6
IC4
IC1
IC2
+18V
J2
J1
IC5B
IC5C
IC6B
IC3
IC5A
R17 220K
C2 .001
IC9
R19 20K
R18 100K
IC10
IC8A
IC8B
Q7
R23 220
R20 1K
R16 1K
R21 15K
R22 5.1K
R15 10K
C3 .47